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NEW YORK, AUGUST, 1895.

EDITORIAL NOTES.

THERE are two reports of economical engine performance in this issue that go to show that improved constructions in boilers and engines have been making great advances during recent years in the economical saving of coal. M. Normand, in a paper before the Institution of Naval Architects, reports the development of a H.P. on 1.56 lbs. of coal per hour, naturally attributing such results to the effective working of the water-tube boiler, and the trial of the Schmidt motor shows that the same power was developed on the consumption of 1.7 lbs. per hour. This latter is the more interesting of the two in that the Schmidt motor is a compound engine, and the saving over other forms of compounds must be attributed to a great extent to the system of superheating that the inventor uses, one of the main features of which is that the temperature of the superheated steam is actually greater than that of the gases as they escape into the stack. This is accomplished, as our readers will recollect, by passing the gases over the superheating pipes in a direction contrary to the flow of the steam, so that the latter is touched by the hottest gases just as it leaves the superheater.

A CONTROVERSY is on between the bureaus of Ordnance and Construction and Repairs in regard to the proposed new battleships. The question involved relates to the location of the 13-in. gun turrets. The Bureau of Construction and Repairs recommends that the ships carry eight 8 in. guns, two of which are to be placed in a turret above and abaft the forward 13-in. gun, and two similarly mounted above and forward of the after 13-in. gun. The Bureau of Ordnance objects on the ground that the blast from these guns will be such as to result in great discomfort if not in actual injury to the crews in the lower turrets. To maintain their position they have made some tests at Indian Head in which a 1-in. plate was deflected about 7 in. by two shots from an 8-in. gun. This they claim proves their position. The Bureau of Construction and Repairs, on the other hand, claim that the plate was placed so much nearer the blast than it would be in the actual construction proposed that the test proves nothing. It will therefore devolve upon Secretary Herbert to decide in this disagreement of the doctors. A report of the test is given in another column.

DOWN-DRAFT FURNACES.

THE statement which is made in Mr. William H Bryan's paper, read at the Detroit meeting of the Mechanical Engineers, and which is republished in another part of this number of the AMERICAN ENGINEER, that "experience in St. Louis leads to the belief that smoke from boiler furnaces can now be abated by practical means, without hardship, no matter what the type of boiler, the character of the work required of the plant, or the kind of fuel used," is made apparently with every evidence of credibility, and after a careful investigation of the subject should attract very general attention from steam users and those who suffer from the production of smoke—and, in Western cities, the latter class embraces most of the population. For at least a hundred years the consumption of smoke has been a subject of constant study and experiment by engineers and inventors, and the devices brought out to effect that desirable result have been innumerable. Some of these would, to a greater or lesser extent, effect the consumption of smoke, but the obstacle which has stood in the way of the general adoption of any of them was the fact—which soon made itself manifest after any of them were used—that it was not profitable to consume smoke. The erroneous assumption that smoke was very wasteful of fuel was generally accepted as being true, whereas careful investigation showed that the amount of waste of fuel due to the production and escape of smoke unconsumed was very little. In St. Louis and Chicago and other Western cities the smoke nuisance has been a very serious one, and legislation of various kinds to prevent or diminish it has been enacted at different times. The result has been that the attention of inventors has been directed to the subject anew, and steam users by the compulsion of the law have been inclined to adopt any device which would reduce or prevent the production of smoke. This has naturally led to many experiments and much investigation, with the result that a number of different forms of down-draft furnaces, described by Mr. Bryan, have been brought out which have produced excellent results, not only in the diminution of smoke, but they show a very material economy in the production of steam and an increase and not a diminution in the efficiency of the boilers. There are certainly results which

"We long have sought but found them not."

One form of these smoke consumers, the author of the paper tells us, has been applied to 1,600 boilers, which is an indication of its success. Tests of one of them and of a common furnace, with a combustion of coal of over 40 lbs. per square foot of grate per hour in each, showed that with the smokeless furnace 6,489 lbs. of water were evaporated per pound of coal, whereas with the common grates only 5,249 lbs. was evaporated. The smoke production "on a scale of 100" was as 74.16 to 3.19. In another test the coal consumed per H.P. per hour with the smokeless furnace was 5.25 lbs., while with the ordinary furnace it was 6.43 lbs. If these results can be obtained without any or little increased expense from other sources, it removes the great obstacle in the way of smoke consumption which has been that it did not pay.

Mr. Bryan concludes his admirable paper with the very conservative observation that "the system in its best shape is not perfect. Much has been done during the last few years in im-

proving details so as to increase the efficiency, durability, and reliability of the apparatus, but there is room for further improvements. Even in its present condition, however, it is well worthy of the careful study of progressive engineers everywhere." To which a confirmatory "Amen" may be added.

THE INTERNATIONAL RAILWAY CONGRESS.

ONLY very meagre reports of the proceedings of the meetings in London have thus far reached this country. At the opening the delegates were addressed by the Prince of Wales, and one of them, who has since returned, is reported in the daily papers to have said that the sentiments of the prince were entirely satisfactory to the Americans who heard them. Later, the delegates were received by the Queen at Windsor Castle, assisted by the prince, and they were entertained at a garden party.

Of the congress itself, *The Engineer* says: "It is not quite easy to regard it as existing for mental improvement. Its proceedings are more those of a great pleasure party than those to be expected from a scientific deliberative body. . . . On Monday (July 1) serious work began in the way of discussion, but it is open to question whether these discussions have added much to the store of general available information. . . . The polyglot nature of the assembly renders the proceedings rather unwieldy. In each section there is a president and two interpreters who sit at opposite ends of the presidential table. The one translates the speeches made in French for the benefit of the English-speaking portion of the audience; the other translates the English speeches into French for the benefit of the foreigners in the audience. As the interpreters are gentlemen of considerable standing, thoroughly versed in the questions discussed, the result is sufficiently satisfactory; but progress is very slow, seeing that everything said has to be said twice over. The arrangement under which the time of the meeting is wholly devoted to discussion, not the smallest portion of a paper or report being read, is quite admirable, and causes no inconvenience whatever. It is hoped that the success of the method will promote its adoption among our own technical societies."

The Engineer also calls attention to one of the rules of the congress "that the author of a paper should come to some definite conclusions at the close of his paper, these conclusions being submitted to the meeting of the section in which the paper is discussed, and amendments are then proposed by other delegates if they so wish." A large proportion of the papers, our contemporary also says, "possess only a secondary interest for its readers, dealing as they do with questions of traffic, management, and such-like, involving little or nothing of engineering." It then gives a brief abstract of the discussions which took place in Room 11, in which the papers on locomotives and other rolling stock were discussed.

The proceedings appear to resemble very closely those of our own Master Mechanics' Association, and very much the same diversity of opinion and inconclusiveness were developed. The kind of conclusions which were reached seemed hardly commensurate with the time, money and labor expended to bring together a "congress" from the four quarters of the globe. Thus it is said that "it was pointed out that if the steel plates were of good quality and not high in carbon, they could be flanged more satisfactorily than iron." Again: "One engineer stated that for smoke-box tube plates he had found that steel rusted more quickly than iron; and after considerable experience he had gone back to the use of iron for this purpose." In the discussion of spark-arresters it was pointed out that "it is absolutely essential for good work that the axis of the blast pipe be exactly in the axis of the chimney, and many an engine has been much improved in working by correcting a slight error in the position of the pipe." Mr. Clerault, of the Western Railway of France, said he preferred a bogie in front of express engines, which could twist and also swing laterally." M. Baudry, of the Paris, Lyons & Mediterranean Railway, said that formerly his company used no bogies, but they were now taking out the leading axles of many engines and substituting bogies. On the Belfast & Northern Counties Road the saving by compound locomotives was about 16 per cent. In the discussion on wheels it was brought out that Mansell wooden wheels failed on the Pennsylvania Railroad, but that 40,000 pairs were in use on the London & Northwestern.

With reference to the accommodation of passengers, "the essential point brought out was that *comfort for all, and not luxury for a few, should be sought for*"—a sentiment which ought to be inscribed in imperishable letters on every railroad station in this land of freedom and equality.

It must be admitted that the papers and the discussions, or, at any rate, that portion of them which have thus far reached this country, are disappointing, and seem to be rather commonplace. So far as their character has been indicated to us who could not attend the meetings there seems to have been but little originality in the reports or discussions that have reached us here, and not much of that kind of ability which manifests itself by collecting material from a great many sources and by a process of mental digestion, shows the conclusions which should be drawn from the facts and the evidence collected. It recalls the close of one of the Master Mechanics' conventions here, after there had been a great deal of talk and much diversity of opinion manifested and but little decisive action. Just as the terminal resolutions of thanks, etc., with which these meetings always end, a member remarked *sotto voce* to those next to him, "I now move that we adjourn, and that we all go home and do as we please." Apparently that will be the consecution of the meeting of the International Railway Congress.

THE ELECTRIC LOCOMOTIVE ON THE BALTIMORE & OHIO RAILROAD.

THE most interesting engineering event of the month of July was the trial of the electric locomotive, built by the General Electric Company in their Schenectady shops, for operating in the great tunnel which the Baltimore & Ohio Railroad Company has constructed under the city of Baltimore. Heretofore this road has had no continuous line through this city excepting one through its streets, which it was permitted to operate only with horses, and that has not been used for some years past. The company was, therefore, compelled to transfer all its through cars which ran between Washington and the West and Philadelphia and New York by a ferry from Camden, at the eastern end of Baltimore, across the northwest branch of the Patapsco River, which forms the harbor of that city to Locust Point, located on its southern side. This, of course, was a serious obstacle to traffic, and as the Pennsylvania Railroad Company some years ago built a connecting line through and around Baltimore, constructed partly in tunnels and partly in open cuts, the Baltimore & Ohio Line was at a serious disadvantage in competing for traffic. To remove this obstacle, in 1890 the company commenced the construction of a connecting road extending from the old Camden Station to Bay View Junction, a distance of 7.2 miles. The actual construction was carried out by the Maryland Construction Company, and the line is owned by the "Belt Line Company," which is doubtless controlled by the Baltimore & Ohio Railroad Company.

The line enters the mouth of the tunnel alongside of Camden Station, under Howard Street, on which formerly a large part of the flour business of Baltimore was done when the only means of transportation were the Canastoga wagons, which brought the produce from Pennsylvania, Maryland, Virginia and Ohio to Baltimore, over the turnpike roads which centred there. It was on this street that the place of business of Rob-

ert Garrett & Sons was originally located, the senior member of which firm was the father of John Garrett, the noted former President of the Baltimore & Ohio Road and the grandfather of Robert Garrett, Jr., who succeeded his father, John, in that office. It was here in the flour business that the foundations were laid of the fortunes which the son and the grandson have since inherited. The tunnel extends under Howard Street from Camden Station and emerges at the northern side of the city and is 7,339 ft. long. The soil under Howard Street consists chiefly of sand, through which run seams of gravel and a hard species of clay, and presented great difficulties in the prosecution of the work.

The operation of such a tunnel with the amount of traffic which it would be necessary to carry through it of course brought up the question of ventilation. Various schemes were suggested, but were abandoned, and the offer of the General Electric Company to construct electric locomotives of a capacity to haul the heaviest trains was finally accepted. The first one of these engines has been delivered, and its trial during the month of July, as we have said, has been the event of the month.

The electrical equipment, as first outlined, was described by the electrical company as follows :

"The locomotives were to operate from Henrietta Street about 1,800 ft. in the open to the portal of the tunnel at Camden Street, and thence to the further end at Mount Royal Avenue, and for 4,600 ft. further on in the open, or a total distance of about 14,500 ft. The locomotives were to join the rear end of passenger trains going north, at Henrietta Street, and push both cars and locomotives through to the second station, from which point the steam locomotive was to do all the hauling. Freight trains were to be pushed the entire distance. The calculations were to be based on a maximum weight of 500 tons for each passenger train, including the steam locomotive, with a speed of 35 miles an hour, and on a maximum weight of freight trains of 1,200 tons at a speed of about 15 miles an hour on a grade of 0.8 per cent. The number of trains each way was to be about 100 a day. An electric lighting plant with large incandescent lamps for the tunnel and arc lights for the stations was also contemplated."

The plan of pushing the passenger trains through the tunnels has been abandoned, in view of the possible results if one of the cars or the steam locomotive should leave the track in front of the heavy electric locomotive travelling at 30 miles an hour.

The power house is located on the west side of Howard Street, east of the tracks leading to the southern portal of the tunnel and south of Camden Station. There are 12 water-tube boilers of 250 H.P. each, built by the Abenroth & Root Company, of New York. The dynamos are driven by four cross compound engines built by the Edward P. Allis Company, of Milwaukee. There are also four high-speed Armington & Simms engines for driving the electric-light plant.

The engines have two trucks each with four driving-wheels 62 in. in diameter and two motors to each truck. The wheel-base of each truck is 6 ft. 10 in., and the total weight on driving-wheels is 192,000 lbs.

A number of tests of the engine have been made, and, as might be expected at first, some failures have been reported. It seems, however, established that it can pull heavy trains, but as yet no intimation is given of the consumption of fuel in doing it, which is, of course, the important economical question. That it will be very great may, however, be expected, as a single engine working at intervals would not be working under the most economical conditions. Even if all the work in this tunnel should be done with electric locomotives, probably not as economical results would be obtained as may be expected if a line was operated with a large traffic and many engines. Before the death warrant of the steam locomotive is read a certificate should be appended to it giving the fuel consumption of its successor. The veracity of electricians and the voracity of their engines is now on trial.

BOOKS RECEIVED.

An Experimental Study of Field Methods which will Insure to Stadia Measurements Greatly Increased Accuracy. By Leonard Sewal Smith. Bulletin of the University of Wisconsin, Madison, Wis.

Proceedings of a National Convention of Railroad Commissioners. Held at the Office of the Interstate Commerce Commission, Washington, D. C., May 14 and 15, 1895. Washington : Government Printing Office, 1895. 80 pp., 5¼ × 9 in.

Transactions of the American Institute of Electrical Engineers. Vol. XI. Meetings of January 7, February 21, March 21, April 18, May 15, 16, 17 and 18, September 19, October 17, November 21, and December 19, 1894. Published by the Institute, New York. 938 pp., 5¼ × 8¼ in.

Report on the Use of Metal Railroad Ties and on Preservative Processes and Metal Tie plates for Wooden Ties. By E. E. Russell Tratman. [Supplementary to Report on the Substitution of Metal for Wood in Railroad Ties, 1890.] Prepared under the Direction of B. E. Fernow, Chief of Division of Forestry. Published by authority of the Secretary of Agriculture. Washington : Government Printing Office, 1894.

NEW PUBLICATIONS.

The Design, Construction and Maintenance of a Marine Boiler. "Shipping World Series." London : *Shipping World* Office. 29 pp., 5¼ × 8¼ in. Price, threepence.

In a note appended to the title it is said that "this series of papers, now published in pamphlet form, was originally written for the assistance of captains and officers intending to take the voluntary examination in steam." If this is the main purpose of the pamphlet, we cannot but feel sorry for the "captains and the officers." The articles consist of a rather miscellaneous assortment of information relating to marine boilers—not in itself bad or useless, but totally inadequate to give persons who are supposed to be entirely ignorant of the subject the information which they would require and which ought to be given in a "series of articles" which purport to be what these are not.

Position Diagram of Cylinder with (Meyer) Cut-off at ⅛, ¼, ⅜ and ½ Stroke of Piston. New York : Spon & Chamberlain. 25 cents.

This is a sectional view of a steam cylinder printed on a card, and with sectional views of the main and cut-off valve used in the Meyer gear and movably attached to the card so that they can slide in relation to the valve face and to each other. A circumferential diagram showing the movement of the crank with arcs drawn with the length of the connecting-rod as a radius for making the connection due to the angularity of the rod, and similar diagrams to indicate the movement of the two valves, are drawn on the centre line of the cylinder and valves. There ought to be some explanatory text go with it. An elementary and clear explanation of the Meyer gear and what the diagram is intended to show would add very much to the usefulness of this publication.

Construction of Stationary and Marine Steam-Engines. (Printed in French.) By Maurice Demoulin. Paris : Baudry & Co., 430 pp., 7 × 11 in.

This book, were it published in English, would be called a practical treatise on the steam engine. It is intended to supply that information regarding the construction of steam-engines that is usually acquired by practical men in the course of their work, without order and without arrangement, and which is not ordinarily taught in the schools ; and, while it has, of course, been impossible to so elucidate the subject under consideration that the reader will have that intimate touch with the subject that is evidently possessed by the writer, all of the information given is of that practical sort so indispensable to any one engaging in active engine construction. The book is not by any means a didactic treatise on the steam-engine. It is written in a perfectly practical way, and avoids those topics that are usually made the subjects of examination, and on which there are already such a multiplicity of books. It takes it for granted that the reader is already familiar with the operation and theory of the steam-engine, and is to a great extent limited to the information required for the construction of an engine, the considerations that should influence the choice of the type to be used and the

determination of the principal dimensions, as well as the proportioning of the principal details.

The theoretical and practical knowledge of the steam-engine is condensed into a single chapter, which is the first in the book. The second chapter treats of the circumstances that should influence the engineer in the choice of the type of the engine to be used. The third chapter is devoted to the determination of the main details of the engine, and to the calculation of the dimensions of the cylinder; and this same system is followed with the frame, the pistons and piston-rods, cross-heads, cranks, shafts, bearings, fly-wheels, valves, condensers, and air-pumps, and the fittings of the machine.

The value of the book lies in the fact that it is not limited to French practice, but has gone abroad for the best examples of steam-engine work that could be found, turning to the United States especially for stationary engines and to England for marine engines. The book is very fully and completely illustrated by process engravings, upon which there are no dimensions, but which serve to show very clearly the form of the parts represented. The book is well printed, and our only regret is that the language in which it is published is not one that is understood by the majority of our readers.

TRADE CATALOGUES.

In 1894 the Master Car-Builders' Association, for convenience in the filing and preservation of pamphlets, catalogues, specifications, etc., adopted a number of standard sizes. The advantages of conforming to these sizes have been recognized, not only by railroad men, but outside of railroad circles, and many engineers make a practice of immediately consigning to the waste-basket all catalogues that do not come within a very narrow margin of these standard sizes They are given here in order that the size of the publications of this kind, which are noticed under this head, may be compared with the standards, and it may be known whether they conform thereto.

It seems very desirable that all trade catalogues published should conform to the standard sizes adopted by the Master Car-Builders' Association, and therefore in noticing catalogues hereafter it will be stated in brackets whether they are or are not of one of the standard sizes.

STANDARDS.

For postal-card circulars.....	3⅜ in. × 6⅛ in.
Pamphlets and trade catalogues.....	3⅛ in. × 6 in. 6 in. × 9 in. 9 in. × 12 in.
Specifications and letter-paper.....	8½ in. × 10¾ in.

The Pilot File System. Keuffel & Esser Company, New York. 28 pp., 5¼ × 9 in. [Not standard size.]

The articles illustrated and described in this pamphlet are letter files and not the abrasive tools used by mechanics. Various forms of files and other appliances for storing and classifying papers of various kinds are explained, and also shelving and cases for storing the files.

Light. 8 pp., 5¼ × 9 in. The Safety Car Heating and Lighting Company of New York have reprinted in an attractive form an article which first appeared in *Trade and Travel*, published by the Commercial Travellers' Club, of New York. It is illustrated with views of the interiors of Pullman and other cars which are intended to show the convenience and comfort which results from the lighting of cars by the Pintsch system. The words of the apostle Peter might be quoted to the commercial traveller: "Ye should shew forth the praises of him who hath called you out of darkness into his marvellous light."

Protection of Grade Crossings of Steam Railroads with Electric Railways and Protection of Facing Point Switches. By Charles Hansel, C.E. The National Switch & Signal Company, Easton, Pa. 26 pp., 7¼ × 10¼ in. [Not standard size.]

This company has here reprinted several articles by Mr. Hansel, their manager—the one on Protection of Grade Crossings of Steam Railroads with Electric Railways, and the other on the Protection of Facing Point Switches. These are followed by the Travis Derailing Switch.

All of the articles are illustrated, and show the methods and appliances employed by the National Company for protecting crossings, etc., and gives a full statement of the reasons for what they recommend. The descriptive matter is all very clear, and there is a refreshing absence of display type and boastful statements which have the savor of the commercial traveller about them. It is printed in excellent taste, and might be designated as a gentlemanly trade catalogue. Its modest appearance and temperate statements incline one to believe all that it contains, whereas the strident character of some examples of such literature incline one to doubt all the statements they contain.

The Peerless Rubber Manufacturing Company, Manufacturers of Superior Mechanical Rubber Goods. New York. 72 pp., 5¼ × 8 in. [Not standard size.]

The uses to which india rubber is now put are many. The tract before us is intended to state the merits and the kinds of goods which this company makes. These include packing of various kinds, gaskets, rings, pump valves, hose for a great variety of purposes, and a rubber cement for air-brake, steam and other hose couplings, rubber and leather belting, matting of various kinds, etc. The only fault to be found with this catalogue is that it is printed in blue ink, the object of which is not apparent.

Illustrated Catalogue of Mining, Milling and Smelting Machinery. Reynolds' Corliss Engines. Manufactured by the Edward P. Allis Company, Reliance Works, Milwaukee, Wis. 120 pp., 6 × 9 in. [Standard size.]

The machinery described here is somewhat out of the range of the American Engineer, and therefore it will receive a mere mention. It includes such things as crushers, rolls, stamps, mortars, concentrators, amalgamating pans, agitators, screens, jigs, furnaces, blowing and winding engines, etc. These are all illustrated with excellent wood engravings and good descriptions.

Willans' Central Valve Engine. M. C. Bullock Manufacturing Company, Sole American Manufacturers. 36 pp., 7¼ × 10½ in. [Not standard size]

The purpose of this publication is to set forth the design, construction, merits and advantages of the Willans engines, which has been extensively adopted in England, but is not so generally known here. With this object in view, the publishers give a perspective view of an engine of this kind which is used for driving their works in Chicago. The opening part of the text is a statement of the chief points of excellence of this engine. This is followed by a chapter called a "Retrospect," in which the processes and reasons are described by which the Bullock Company was led to abandon the Corliss type of engine for electric light and power uses for the Willans plan. The data of tests of such engines made by Professors Kennedy and Unwin are given on page 13, which show a consumption of feed water per I.H.P per hour of 19.11, 18.7 and 12.74 lbs. respectively. A diagram is also appended which is a plan of engine-room showing the relative space occupied by a 380-H.P. Corliss engine, belted directly to two generators, and that required for a 365-H.P. central valve engine, coupled direct to a generator. The space occupied is 1,724 and 216 sq. ft. respectively. A view follows this, showing the interior of the St. Pancras vestry, Regents' Park Station, in London, with a description and plan. After this the reader is given a description of the engine occupying five pages and a sectional view which fills another We are not able to speak in very high commendation of either of these. The description is not a model of lucidity and the engraving is execrably bad. Lists of engines in use, reports of tests, and "queries answered," with a number of half-tone engravings of engines—a number of them from photographs taken at the World's Fair in Chicago—complete the volume. The engravings are printed in blue ink, which it is thought detracts somewhat from the distinctness of the prints. The great defect of half-tone engravings is want of definiteness. The paler the ink with which they are printed, the more indistinct they become, and the converse is also true that the blacker the ink the better for this kind of work. The paper and press work are excellent, although with different ink the illustrations, it is thought, would have appeared to better advantage, excepting the sectional view, which no ink nor anything else could improve. Our criticisms are of the catalogue and not of the engine. In another pamphlet the makers publish a very long list of those which have been installed in England, and a shorter one of those used in this country, which form, perhaps, the strongest testimonial which could be given of the success of this type of motor.

Catalogue and Price-List of Theo. Alteneder & Sons, Manufacturers of Drawing Instruments, Philadelphia. 111 pp., 6 × 9 in. [Standard size.]

On the title-page of this catalogue it is announced that the firm was "established" in 1850, and consequently it is now in its forty-fifth year. The opening chapter, therefore, is very

appropriately a history of the development of the instruments made by the firm. The peculiarities—especially of the "Alteneder patent point"—are fully described and illustrated, and other peculiarities of construction are also explained. The observations about drawing pens will be especially interesting to draftsmen, as there is no one instrument that is the cause of so much "botheration" as the ordinary pen which every draftsman must use. The evolution of the "spring hinge ruling pen," which the Messrs. Alteneder make, and which permits the blades to be separated and cleaned without moving the adjusting screw, is fully described, and the present perfected instrument is illustrated. The evil effects of corrosive ink is also pointed out, and the lesson is enforced by engravings which represent the magnificent views of the blades of pens which were sent to this firm to be repaired, and represent in material form, what probably assumed the character of a moral, or, rather, immoral, incitement to profanity in the persons who had used the pens.

Referring to the materials of which instruments are made, this firm do not speak approvingly of aluminium, but advise against its use. This metal, they say, "when pure is very soft—somewhat like tin. Its surface is so easily abraded that it soils the hands, and, while it does not tarnish as readily as German silver, the perspiration of the hands will rapidly corrode it." When hardened with a sufficient quantity of copper, silver, or other metal, the aluminium forms less than 15 per cent. of the composition, so that there is but little advantage gained in lightness. They recommend this metal, however, for triangles and the handles of ruling pens.

All the different classes of instruments made by this firm are illustrated and described, and they embrace a large assortment. Among these is a leather pocket case for packing and carrying instruments. This has an ordinary wooden block with indentations to receive the instruments, with an outside covering of morocco. The need of some such device most draftsmen probably have often felt when called upon to pack up their "tools" in a hurry and carry them in a trunk or "grip-sack" or in their pockets.

The only instrument represented in the book which we feel like criticising is their beam compass. They still adhere to the traditional type of that instrument, which is simply infuriating, because every time the screw is slackened which holds the sliding head to the beam the head becomes detached and must be held in position. In the RAILROAD AND ENGINEERING JOURNAL for March, 1890, a form of beam compass was illustrated, which the writer has used for 40 years with very great satisfaction. If some maker should bring out an instrument of this kind, they would be conferring a great benefit on the draftsmen's fraternity. The other feature about Messrs. Alteneder's very excellent catalogue which we are inclined to criticise is the binding. The sheets are fastened together by wire, so that the book does not open comfortably, but it is almost necessary to pry the pages apart. A good many binders seem to think that the purpose of binding is to keep books *closed*, whereas every reader will agree with us that what should be aimed at is to have books open readily and comfortably.

LOCOMOTIVE FOR THE MEXICAN RAILWAY.

To the Editor of THE AMERICAN ENGINEER AND RAILROAD JOURNAL:

It seems to me that you have overlooked one very important defect in your remarks on the locomotive for the Mexican Railway in the May number of THE AMERICAN ENGINEER.

You speak of the advantages of the plate frames and underhung springs, but you don't state that the particular underhung springs referred to are apparently *without equalizers!* As you know, the engines in use here on all the railways are most of them of English make, and the roads are owned in England and Europe and operated by English or European officials, still they find it necessary to put a Bissel truck under their six-coupled freight engines, so that they are practically moguls. Again, the results obtained with American equalized engines have been so much more satisfactory than with the unequalized English (old type), that both managers and motive-power superintendents insist on having new English engines equalized.

During my five years' stay here I have been very much pleased with the working of the locomotives used by all the roads running out of Buenos Ayres for their local traffic. I refer to a class of engines much resembling that illustrated in your journal on page 153 of Vol. LXVII (March, 1893). These engines are of the ordinary eight-wheeled type with the frame extended behind, carrying a very short tank, but one having considerable water-carrying capacity combined with the side tanks above the running boards, which are not carried up very high and do not saddle the boiler. Under the extended frame carrying the tank is a single pair of wheels, generally considerably larger than the leading truck wheels.

Engines of this class are almost never turned, and may be seen to enter the central stations here in Buenos Ayres with heavy local trains of seven, eight, or 10 American cars, running both backward and forward, and generally uncoupling from one end of the train simply for the purpose of coupling on to the other end, and leaving again in a few minutes on another run of 10, 15 or 20 miles or more.

I have often thought that were I ever to occupy a position on a railway at home again that had a heavy suburban traffic, I should do my best to have some locomotives of the same general class tried.

It may interest your readers to know that the heavy through night trains here are made up of American sleeping cars almost entirely, and drawn by the English moguls before mentioned. During the summer months I have seen, night after night, two trains of from 10 to 15 eight-wheeled cars go out on the Southern Railway, each drawn by a large freight mogul with the Bissel truck *not* equalized with the front drivers; and the night trains for and from Rosario, on the Rosario Railway, made up of from nine to 12 eight-wheeled cars (from four to seven being sleepers) daily pass our factories, drawn by the same style of English moguls that are used on the same road for freight traffic.

Yours very truly,

BUENOS AYRES, June 7, 1895. W. V. B.

TRUTHS TO KNOW WHEN BUYING BOILERS.

[IN response to "Facts," a pamphlet issued by the Babcock & Wilcox Company, and partly reprinted in these pages, the Hogan Boiler Company has issued a counterblast with the above title; and as we believe in free discussion, the following is a reprint of it, excepting that the name of a certain company has been omitted when it occurs several times and the references to it have been made impersonal.—EDITOR AMERICAN ENGINEER.]

The provision for the combustion of the fuel and the distribution of the heated gases in relation to the heat absorbing surfaces of steam boilers has received little if any attention. No change has been made since the first forms of the Scotch marine boiler, of one of the types of the "*straight*" water-tube boiler, and the horizontal tubular boilers were built. In these boilers the space beneath the heating surfaces above the grate varies in height from 14 in. to 28 in.

A COMPARISON.

The proportional areas of the flue tube openings in marine boilers and between the water tubes in water-tube boilers of one type varies from 22 sq. in. to 35 sq. in. per square foot of grate area.

In the Hogan stationary and marine water-tube boilers the space beneath the heating surfaces above the grate is from 18 in. to 42 in. in height, and the flue area around the water tubes is from 90 sq. in. to 50 sq. in. to each square foot of grate, the areas reducing as the distance from the grate increases.

THE EFFECT.

The results of this marked difference in design in the Hogan water-tube boiler as compared to other boilers may be summarized:

1. In the Hogan boiler, a large volume of gases at relatively high temperatures is maintained around all the tubes and heating surfaces.

2. In the Hogan boiler, with a forced draft of 1 in. or 2 in. of water pressure, a square foot of heating surface will evaporate twice the quantity of water that a square foot of heating surface will evaporate with a forced draft of 6 in. to 8 in. of water pressure in a Scotch marine boiler or one type of water-tube boiler.

REPAIRS NEEDED.

In the Scotch marine boilers, the intense temperatures due to high pressure forced drafts produce leaks around the tube-plates against which the heated gases are impinged, combustion chambers and their stays are irregularly strained and repairs are soon needed.

In the "*straight*" water-tube boiler of the type referred to, the expanded joints in the headers are strained, the tubes sag, bend down and split, on account of the excessive expansion of the "*straight*" tubes when exposed to high temperatures.

NO DISTORTION.

In the Hogan water-tube boiler the formation of the tubes is such that the most intense heat will not strain the expanded

joints or distort the form of the tubes—the location of the expanded joints prevents any impingement of the heat on the tube-plates. In this boiler there are no obstacles such as headers, stayed tube-plates, etc., to the free expansion of all tubes.

HARD SCALE.

In the "*straight*" water-tube boiler of the type referred to, as well as in the Scotch marine—and it may be said in all other boilers except the Hogan water-tube boiler—the feed water with its foreign matter and impurities is delivered into those boilers in such a manner that when precipitation takes place the sediment falls on the surfaces exposed to the heat of the fire and the heated gases and is baked into hard scale.

SCRAPERS.

In a pamphlet recently issued by the Babcock & Wilcox Company, of New York, this condition is admitted to exist in the water-tube boiler of that company's manufacture. It is claimed that a "*straight*" tube is a necessity, notwithstanding its dangerous resistance to expansion and its ultimate distortion into a bent form. This "*straight*" form of tube when the space in front of the boiler is as long as the tube, permits the use of a long scraping bar with which the scale, which forms on the surfaces of the "*straight*" tubes and sometimes fills them up solid, can be knocked and pushed out of the tubes through the header at the back end.

"SELF CLEANSING."

It is also reasonably claimed that no water tube in a steam boiler, be it "*straight*" or bent, can be "self-cleansing." This claim by some boiler-makers for the existence of "self-cleansing" water tubes in steam boilers is probably based on the high and impracticable velocities which the late Mr. Babcock endeavored to prove to exist by the use of myriads of figures.

PRECIPITATION.

Whenever the precipitation of the foreign matter in water takes place and the sediment is permitted to come in contact with surfaces exposed to the heat of the fire, heated gases or steam, hard scale will form, and will have to be removed in a manner similar to that used in boilers of the Babcock & Wilcox type, or it will have to be chipped.

WATER PURIFIED.

If the foreign substances and sediments held in suspension in water are not allowed to precipitate or come in contact with the surfaces in steam boilers which are exposed to the heat of the fire and the gases, no scale will form on these surfaces.

In other words, if the water is purified by precipitation taking place before the water comes in contact with the surfaces exposed to the heat, no hard scale will come into existence on these surfaces, and no cleansing with a scraper will be or is necessary.

BELOW THE WATER LEVEL.

In the Hogan stationary and marine water-tube boilers the feed water enters the inductors and passes thence to the circulating tubes, where precipitation takes place below the water level and at a temperature within five degrees of that of the steam. The circulating tubes are not exposed to the heat of the gases. The results of the precipitation deposit in the external part of the distributing drum, which is not heated, and pass to the mud drum, which is an external vessel and not exposed to any heat.

PRACTICAL.

The heating tubes in the Hogan water-tube boilers are therefore not "self-cleansing," and do not require the use of a scraper or pick as in the "straight" water-tube boiler. This has been demonstrated in practice. A Hogan water-tube boiler and a "*straight*" water-tube boiler are located in the same city. Each boiler uses the city water. Every month the straight tube boiler is cleaned, scraped and picked. Scale from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. in thickness is regularly removed. The Hogan boiler has now entered its second year. Three examinations have been made and no scale has been found. A soft deposit has been found in the distributing and mud drums, but no hard scale has been brought into existence.

BURSTING.

If the "*straight*" water-tube boilers referred to are not cleaned in two months, even when using rain water, dangerous and fatal results have been the consequence. Horizontally inclined "*straight*" water-tube boilers of this type may be described as packages of tubes crowded together, which soon bend and sag into irregular forms, accumulate and fill with scale previous to burning and bursting. Such surfaces cannot be considered better than packages of bent tubes which do not change their form, accumulate and fill with scale before burning and bursting. Such are the boilers which have been offered to steam users, until the introduction of the Hogan water-tube boilers.

PICK AND HAMMER.

A boiler of the horizontally inclined "straight" water-tube type or of any form in which it is admitted by the manufacturers that scale accumulates on the heating surfaces and becomes hard and has to be removed by scraper, pick and hammer is dangerous, is uneconomical in its operation, and its durability is purely accidental.

WATER SURFACE.

The extent of the surface of the water from which the steam as it is produced has to escape in the marine boiler as in the water-tube boiler of this type and in other boilers is the same under all conditions of firing. Thus, if the water surface is 60 sq. ft. in area, and apparently sufficient when burning 12 lbs. of coal per square foot of grate surface, this same area of water surface is supposed to give off double the quantity of steam when using 24 lbs. of coal per square foot of grate. The effect of this limitation of water surface is great agitation of the water, which takes place under either conditions of firing as indicated by the motion of the water in the gauge glass and by the wet condition of the steam.

DELIVERY OF STEAM.

In the Hogan boiler each tube delivers above the water surface the steam as it is produced. There is no hindrance in the form of water to the exit of the steam from each tube. The higher the temperature of the gases the more rapidly steam is produced, the greater the tendency to superheat the steam. Wet steam cannot escape from a Hogan boiler. A mechanical steam extractor relieves the steam from the water which falls back and passes down the circulating tubes.

"SECTIONAL."

A boiler composed of the least number of parts is more desirable than one composed of many. A boiler composed of one or more steam shells, "straight" 4-in. tubes, cross boxes of irregular forms, headers with innumerable covers and joints, cast mud drums with a half dozen or more connections, a dozen or more connecting nipples, buried in a mass of brick-work, covered with soot on the flue side and with scale on the water side, may be said to be a boiler of the past, no matter how many may now be in existence, and such a composition of parts for a steam boiler is fully entitled to the term "sectional."

A UNIT.

A properly designed steam boiler consists of one steam cylinder, 2-in. bent tubes, two distributing drums, one wrought iron or steel mud drum with two connections and five manhole covers, all placed above the grate level. The tubes are directly above the grate, and no soot accumulates on them on account of the intense heat, and no scale forms on the water side of these tubes because no sediment is permitted to enter these water spaces. The whole is enclosed in non-conducting material. Such a boiler is a *unit* and in no sense "*sectional*." This is the Hogan stationary and marine water-tube boiler.

REMARKS.

The Hogan water-tube boilers are the same for land uses as for marine purposes.

In some straight water-tube boilers the 4-in. tubes were discarded and replaced by smaller tubes when this class of boiler was put on board ship.

The Scotch marine boiler, when used on land, is exactly the same as when used at sea.

What is bad on land in a steam boiler is equally as bad at sea. What is good at sea in a steam boiler is equally good on land.

"TRUTHS AND FACTS."

The publication of the pamphlet "Facts" is most opportune, as it is most desirable that steam users should be informed that the horizontally inclined "*straight*" water-tube boilers are accumulators of scale and that the scale cannot be removed or reduced only by the use of scrapers, picks and hammers.

Those about to buy steam boilers should read "Truths," "Facts," and the following articles in the *Boiler Review*—viz., No. 1, pages 28 and 43; No. 2, page 85; No. 3, pages 125 and 130; No. 4, pages 146, 187 and 194. It will be then readily seen what is the difference between the term of bluff, "Facts" and the statement of "Truths."*

* THE AMERICAN ENGINEER should be included in these sources of information.—EDITOR.

NOTES AND NEWS.

Fast Railroad Time in England.—Arrangements have been completed for running, beginning next month, a train to be known as the American Special Express. It will make the run from London to Liverpool, 201 miles, in three hours and 50 minutes, and, northbound, will make close connections with the transatlantic steamers. The train will make no stops, and its schedule time will be 45 minutes faster than that of other express trains between the two cities.

Bearings for Railway Cars.—From some experiments made on the lubrication and wear of bearings by E. Chabal, on the Paris, Lyons & Mediterranean Railway, he draws the following conclusions:

The result of the tests made showed that the wear of white-metal bearings was 50 per cent. less than in the case of bronze bearings. The tests also showed that, by the use of white-metal bearings, a diminution of 20 per cent. on the resistance of fully-loaded coal wagons, forming trains weighing 300 tons, travelling at speeds of 16 miles to 26 miles an hour, was given; that, as the speed increased, this gain was diminished, but remained always 5 per cent. less. As a consequence of these tests, the Paris-Lyons-Mediterranean Company in 1893 abandoned the use of bronze bearings for carriages and wagons, and adopted white-metal bearings.

A Test of Schmidt's Superheater.—In our issues of April, May, and July of this year we have given accounts of the Schmidt superheater and steam-engine, which has attracted some attention on account of the success that has been attained in the use of superheated steam. In a recent issue of the *Revue Technique* there is an account ot a test that has been made with the device in regard to which we cull the following particulars: The engine subjected to the test had a cylinder diameter of 12¼ in. and a stroke of 19.7 in., and was run at the average speed of 116.3 revolutions per minute, developing 72.56 I.H.P. and showing 62.6 H.P. at the brake. The pressure at the boiler was 167.4 lbs. per square inch, and the temperature of the steam was 660° F. on leaving the boiler, and 605° on entering the engine. The results obtained on tests, lasting for about seven hours, showed that the consumption of water was 12½ lbs. per effective and 10.8 lbs. per I.H.P. At the same time the consumption of coal was 1.7 lbs. per effective and 1.4 lbs. per I.H.P. per hour.

Nickel Steel for Boilers.—Some time ago the Government asked bids for some of the leading steel makers on 20,466 lbs. of steel to contain not less than 3 per cent. of nickel and to meet specifications as follows: Tensile strength, 80,000 lbs.; elongation of at least 25 per cent. in 8 in.; and an elastic limit of at least 50,000 lbs. per square inch. Owing to the very rigid requirements, only two firms bid on the work, these being Carbon Steel Company and Carnegie Steel Company, Limited, both of Pittsburgh. The Carbon Steel Company were ready to guarantee an elongation of 25 per cent. in 2 in. instead of 8 in., and consequently their bid, being informal, was not considered. The work was placed with the Carnegie Steel Company, Limited, at 5½ cents per pound, delivered, Washington, D. C. The plate is about 1¼ in. thick, and is for the armored cruiser *Chicago*, which is to have an entire new set of boilers. The firm rolled eight plates, but these were rejected on three different inspections as not coming up to specifications. On the fourth test one of the plates is said to have showed a tensile strength of 86,000 lbs. to the square inch, and to slightly exceed the severe requirements in reduction of area and elongation.

The Result of Working Eight Hours per Day.—Mr. Brunner, of the firm of Brunner, Mond & Co., sends to the London *Times* an interesting report of the result of a five years' experience of the eight-hour rule in his works. He says that at first the wage-cost per ton went up, then dropped, and is now as low as it was in 1889, the last year of the twelve-hour day. In other words, the men get as much work done in eight hours as they used to get done in twelve. That this is not merely the result of a coincidental improvement in machinery or the methods of manufacture is vouched for by the managers of the works, who have considered the point. Their opinion that, though the men work less hours, the efficiency of their work is not diminished, is supported by their report as to the improvement in greater regularity of attendance, increased application, and improved health among them. The men used often to be irregular and drunken; these offenders are now rare. "The men come down to their shifts regularly, and they come sober." In the long double shift at the end of each week, which is necessary for the work, the men used often to be found asleep. This does not occur under the new conditions. Lastly, the health of the men has much improved. "The improvement in the men's looks, and especially in their gait when leaving the works at the end of the shift, is very marked."

Records of Inventions—In an interview with Mr. Charles F. Brush, the distinguished electrician, which was recently published in the New York *Herald*, he is reported as saying that he had "no doubt that the heads of the Patent Office are honest, but I have had a number of experiences which lead me to believe that the subordinates sometimes allow important information to leak out. I have applied for patents again and again, only to find interferences filed before they were granted, and it is only through my great care in keeping records of my work that I have been able to secure a number of my inventions. Take the arc light. While I was working upon it and attempting to make it commercially profitable, I kept a very full journal of all my experiments. I recorded everything from day to day, and dated it, and had witnesses called in to sign the records. This I found of immense value to me in my patent suits. I had 200 of them, and gained all except one."

This practice of keeping a journal of an invention is one which may be followed with advantage by all inventors, and records made in this way may be of very great value in establishing priority of discovery, which is so essential to the validity of a patent.

Superheated Steam.—In giving the results of their protracted experiments with saturated and superheated steam, the Alsace Union of Boiler Owners say that, theoretically, it bas never been denied that superheated steam should give a higher efficiency than saturated, yet from apprehension of the cylinder becoming damaged by the high temperature, for years no experiments were undertaken with superheated steam. Subsequently, however, after numerous trials, the oldest engine even was found capable of being safely used with superheated steam, and not only without injury, but more economically than with saturated. It is also declared by the Union that in installing a superheater care is essential that the advantages gained are not lost either by less perfect combustion or by greater radiation losses—the cost of the superheater not to exceed, of course, the saving obtained in coal consumption; the superheater to be connected with the boiler, so that both can be fired from the same furnace; and, after leaving the superheater, the gases should come in contact with the heating surface of the boiler, and, lastly, with the heating surface of the economizer. Further, these experiments showed that the use of superheated steam does not exclude the use of steam jacket. Though both superheating and steam jackets were used, yet condensation in the high-pressure cylinder occurred. The use of low pressure, 7½ atmospheres, did not give such good results as the use of high pressure, 11½ atmospheres.

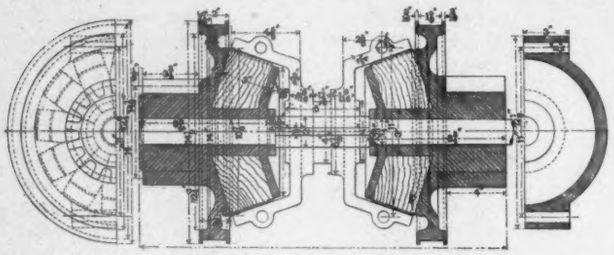
Oil-Burning Locomotive.—Another locomotive for burning oil has been tried on the Southern California Railway. It is the invention of William Booth, formerly Master Mechanic of the Peruvian Central Railway, who has been assisted by Master Mechanic Prescott, of the Southern California Line. In a somewhat brilliantly colored account of it in the Los Angeles *Express*, it is said that "the oil-tank holds a little over 5 tons of oil, and is firmly located inside the water-tank—that is, the water surrounds the oil reservoir. There is 6 ft. of water on the back end of the tank, 18 in. on the sides and front, and 6 in. on top. It is provided with an oil-tight manhole and has a gas vent, so that any amount of shaking about or even upsetting will not cause the oil to escape. Provisions for safety from fire or explosion are still further secured by two automatic safety-valves, one on the top and the other on the bottom of the tank. In case of accident breaking loose the tank from the engine, a rope on the top valve and a chain on the bottom one shut the safety valves and cut off the flow of oil instantly, keeping it confined to the inside tank. Two burners are used with two steam-jet atomizers."

It is said further that "the new equipment is safer than using coal; steam can be raised quicker and better maintained; there is no obnoxious smoke, and no destruction of private property by sparks, as sparks are neither emitted from the smoke-stack nor dropped from the fire-box"—all of which sounds like an old, old story.

Gas Engines.—Treating of gas engines as at present employed in England, Mr. Donkin has stated before the English Institution of Gas Engineers that such engines are usually made there in sizes ranging from ¼ to 600 I.H.P., and there is a marked increase constantly in the sizes and numbers sold. The use of ordinary lighting gas is customary in sizes up to 10 H.P., but for larger sizes a small convenient apparatus has been devised for the production of a gas that cannot be used for illuminating purposes, but which gives very

economical results when burned in an engine cylinder. For this article, termed a generator gas, the best fuels employed in its production are found to be anthracite coal and gas coke, as they yield no tar. The thermal efficiency is low, it having about 160 heat units per cubic foot, as compared with 615 to 630 of London lighting gas, and consequently about four times the quantity is required to produce the same amount of power. The great quantity obtained, however, together with the small amount of depreciation and labor involved in production, render it in many cases comparable in cost to gas at 20 cents per 1,000 ft. The disadvantage is acknowledged that gas engines cannot be started under full load, requiring the use of friction clutches, in most instances having but one impulse to each four movements of the piston, necessitating greater weight per H.P. than with steam; on the other hand, the gas engine can be started instantly, and there is no danger from fire when it is shut down.

Friction Clutch for 5-Ton Crane.—In our last issue we published an illustrated description of a 5-ton crane built at the shops of the Baltimore & Ohio Railroad. We now supplement this with an illustration of the friction clutches used for hoisting and raising the boom. It will be seen that the construction is very simple. The pinion on the outside at the left has a pitch diameter of 6 in., with 15 teeth of 1½ in. pitch, and is used for hoisting the boom. The mate at the other



FRICTION CLUTCH FOR 5-TON CRANE.

end has a diameter of 6.27 in., with 13 teeth of 1½ in. pitch, and does the hoisting. Each pinion is cast solid with the brake-wheel, and the shell for carrying the hardwood friction-blocks. These friction-blocks are put in with the end of the grain presented to the wearing face of the shoes and with an original projection of ⅛ in. beyond the face of the shell. In other respects the construction of the clutch with all of the dimensions is shown by the engraving.

Locomotives on Prussian Railroads.—At a recent meeting of the German Society of Mechanical Engineers, Privy Counsellor Stambke gave the following information respecting the experience had on the Prussian State Railroads with the 519 compound locomotives in use thereon, and the conclusions arrived at by the mechanical officers respecting future locomotive construction: "All compound locomotives, under similar circumstances, when under full headway, develop a greater capacity than ordinary locomotives; at the same speed they exert greater traction, or with the same traction they make greater speed. They save fuel and water. On the other hand, ordinary locomotives have greater starting power than compounds, and, therefore, attain their standard rate of speed quicker. The time and space required for them to get under way is therefore less than with compounds, which latter, when stops are frequent, often find it difficult to make up the time lost in starting. A compound locomotive which is arranged to use steam like any ordinary one in starting can get under way as well as the latter. It is harder to start tight-coupled express and passenger trains than freight trains, and a failure of the draft-rigging, and a consequent lengthening of the time of getting under way, is therefore to be feared more with the former. The Prussian State Railroads have, therefore, come to the following conclusions: 1. Express locomotives hereafter are to be generally constructed on the compound system. 2. In all tank locomotives and engines for branch roads the compound system is to be excluded. 3. For freight engines used chiefly for long runs the compound system is to be employed. 4. For freight engines used chiefly to serve among the coal districts, the compound system will be avoided for the present. 5. For passenger engines with tenders, in view of the fact that they must make frequent stops, no decision is made yet. The experiments will be continued."

The Invention of the Telephone.—According to *Nature*, Professor D. E. Hughes, F.R.S., in the course of a few remarks made at the recent banquet given by the staff of the National Telephone Company, some points in connection with the early history of telephony were mentioned. The text of the speech is published in the *Electrical Engineer* for March 22, and the following note from it is interesting. Professor Hughes said:

"The earliest record of a perfect theoretical electric telephone was contained in Du Moncel's 'Exposée des Applications,' Paris, 1854; when M. Charles Bourseul, a French telegraphist, conceived a plan of conveying sounds and speech by electricity. 'Suppose,' he explained, 'that a man speaks near a movable disk sufficiently flexible to lose none of the vibrations of the voice, that this disk alternately makes and breaks the current from a battery; you may have at a distance another disk which will simultaneously execute the same vibrations.' Unfortunately M. Bourseul did not work out his idea to a practical end, but these few words contain the shortest possible explanation of the theory of the present telephones."

It is now exactly 30 years since Professor Hughes first experimented with a working telephone. In 1865, being at St. Petersburg in order to fulfil his contract with the Russian Government for the establishment of his printing telegraph instrument upon all their important lines, he was invited by his Majesty the Emperor Alexander II. to give a lecture before his Majesty, the Empress and Court at Czarskoi Zelo, which he did; but as he wished to present to his Majesty not only his own telegraph instrument, but all the latest novelties, Professor Philip Reis, of Friedericksdorf, Frankfort-on-Main, sent to Russia his new telephone, with which Professor Hughes was enabled to transmit and receive perfectly all musical sounds, and also a few spoken words, though these were rather uncertain, for at moments a word could be clearly heard, and then from some unexplained cause no words were possible. This wonderful instrument was based upon the true theory of telephony, and it contained all the necessary organs to make it a practicable success. Its unfortunate inventor died in 1874 almost unknown, poor and neglected; but the German Government have since tried to make reparation by acknowledging his claims as the first inventor, and erecting a monument to his memory in the cemetery at Friedericksdorf.

The Force of the Blast from an 8-in. Gun.—Recently, with a view to the practical determination of the effect of a blast from heavy gun firing over a protective plate, Commodore Sampson had a series of experiments made at the Indian Head Proving Ground. The Indian Head experiments were interesting, and are the first of the kind ever held in this country or abroad. Lieutenant Mason, the officer in charge of the proving ground, conducted them. An 8-in. gun was employed. Under its muzzle was placed a 7-in. armor-plate, which was 8 ft. square, and weighed about 8 tons. The centre of the plate was 20 in. in front of the muzzle and about 4 ft. below it. Over the plate, and nearly parallel with it, was secured a 1-in. wrought-iron plate, 74 in. long × 68.5 in. wide. It weighed about two-thirds of a ton, and was supported at each corner by a 2-in. armor bolt, screwed into the corner holes in the back of a 7-in. plate below. The corner holes in the bottom of the plate were not directly below the holes in the corners of the wrought-iron plate. Consequently they were bent to bring their upper ends into proper position. The centre line down the length of the 1-in. plate was parallel with the axis of the bore of the gun, prolonged .25 of an inch to the right and 24 in. below, the surface of the plate being inclined 1° with the horizontal, the same as the gun. The muzzle of the gun projected from the rear of the 1-in. blast plate 17.5 in. Two rounds were fired.

In the first round the charge of powder was 100 lbs., the muzzle velocity 2,018 foot-seconds, and the pressure 16 tons. The elevation of the gun was 1°. The wrought-iron 1-in. plate was bent downward at right angles to the line of fire, along its central transverse line, the centre of the plate being forced down by the blast 3.93 in. A slight rotary movement to the left was also given to the plate. The 7-in. armor was not moved at all. In the second round the charge of powder was 107 lbs., the muzzle velocity 2,000 foot-seconds, and the pressure and elevation the same as in the preceding round. The blast plate was in the position produced by the first round. The effect of the second blast was merely an augmentation of that of the first fire. The lower plate was not moved in the least. After the second round the support of the right-hand rear corner retained nearly its original position. The other three bolts had twisted to the right nearly 45°. The second round crushed the plate downward about 7 in., making the extreme deflection about 10 in.

The North Sea and Baltic Canal.—The canal is a little over 61 miles in length, and is throughout on the same level as the Baltic, where tides are unknown. Hence only two sets of locks have been necessary, one at each end, and even of these two the Holtenau locks may be treated almost as non-existent, as their gates will have to be closed only on the occa-

sion of storms on the Baltic affecting the height of the waters there—say on twenty or twenty-five days in the year. Thus for vessels proceeding westward there will be an absolutely clear and unobstructed course as far as Brunsbüttel, and here, except for three hours each day at ebb tide, the lock-gates will have to be kept closed on account of the tidal changes in the Elbe, though vessels will be able to pass through at any time, subject to the ordinary delays. The breadth of the canal at the water-level is 197 ft. and at the bottom 72 ft. 1¼ in., thus allowing of a man-of-war and any ordinary merchantman passing one another wherever they may happen to meet, while at six different points along the line of route there are "bays," where the increase of superficial breadth from bank to bank to 328 ft. and of the bottom breadth to 197 ft. for a distance of 820 ft. will allow of the passing of two men-of-war without fear of collision. The depth of the canal is 29 ft. 6 in. The old Eider Canal, which has been incorporated in the new one as far as Rendsburg, save for various windings, now happily avoided, had besides its six sets of locks a depth of only 10 ft. and a breadth of a little over 100 ft. The superiority of the new canal, with its far greater dimensions, almost unobstructed course, and its outlet into the Elbe at a point where the river has a depth of about 40 ft., is clearly manifest.

As regards the work of construction, the most interesting feature is perhaps to be found in the great terminal locks, and of these the locks at Brunsbüttel claim first consideration. They are protected from the current of the river by two moles, the heads of which are 1,247 ft. apart, thus allowing a good space for entrance into the outer harbor, which has a breadth of 328 ft. and a length of 1,312 ft. Here the vessels that may have to wait their turn before passing through the river will be accommodated. The locks themselves are double, the one set lying parallel with the other, divided by some massive masonry, under which are several tunnels for the hydraulic machinery to be used for opening or closing the gates and other purposes. The width of each lock is 82 ft., the depth 30 ft., and the available length, when the gates are closed at each end, is 492 ft.—dimensions adequate to allow of the passing through the locks at any state of the tide of the largest ironclads.

The Properties of Coal as Fuel for Steam Boilers.—Some manufacturers usually require their coal merchants to furnish material which shall contain (1) a certain proportion of lumps, (2) a small proportion of ash, (3) a certain percentage of volatile material, usually about 20 per cent. Accordingly the pit-owners only guarantee these three elements.

The moisture contained in the coal is of considerable importance, and also its freedom from stones and slate; but perhaps the number of heat-units generated by complete combustion is the best measure of the value of a coal. Lump coal has a greater calorific value than small coal or dust. It is proposed that lump coal be defined as that which is retained on a sieve of 1.4 in. mesh.

All coal—even coal fresh from the mines—contains a certain amount of moisture, from 1 per cent. to 6 per cent., which is not altogether unfavorable for combustion; the percentage of moisture must not, however, fall outside certain limits. Some railway companies pay only for the dry coal, and make a moisture test on all coal received, rejecting that in which the moisture exceeds 7 per cent.

The quantity of ash and cinder is of great importance; not only has this to be paid for and transported, but on being put into the furnace it hinders combustion and adds considerably to the work of the stokers. The railway companies specify 6–8 per cent. of ashes and cinders, pay 0.5 franc per ton for 1 per cent. less, and deduct 0.5 franc per ton for 1 per cent. more, and reject any delivery containing more than 10 per cent. ash and cinders.

The proportion of volatile components influences the ease of kindling the coal and the quickness with which it burns. In sugar works 20–22 per cent. of volatile components is demanded. If the draft is strong 15 per cent. may be sufficient, while with weak draft 25–28 per cent. is required. A coal containing too much volatile material burns too quickly without giving up usefully the heat due to its combustion. A mixture of two coals containing respectively too little and too much volatile material should be rejected. The wider commercial use of calorimeters is recommended, a coal giving less than the specified number of calorics to be rejected.

The fusibility of the clinker is an important point to be considered, the author stating from his own experience that coal which, in a lightly worked boiler with weak draft, gave no fused clinker, in a hard forced boiler with strong draft gave a considerable quantity of clinker.

A specimen form of contract for coal is given at the end of the paper.—*Abstract of article in Mittheilungen aus der Praxis der Dampfkessel- und Dampfmaschinen-Betriebes*, 1894.

Smoke Prevention.—The serious difficulty with nearly if not quite all the appliances which have been devised for consuming smoke is that they do not pay. The heating capacity of smoke is so little, that it is cheaper to waste the smoke than to utilize the small amount of potential heat there is in it; besides this, some portions of the smoke are incombustible. Colonel Dulier has devised a system of smoke prevention, which has been described in the London *Times*, by which the smoke after leaving the furnace is mixed with steam in an ascending flue, and then in a descending flue is met by a very fine spray of cold water. The result is that the larger part of its constituents are dissolved or precipitated, and escape with the water into the drains, from a tank at the bottom of the descending flue. Any residue passes out with a certain amount of steam from a chimney fixed in the tank. A rough proof of the efficacy of the arrangement is afforded by the fact that a piece of white cloth may be held for some minutes over the top of this chimney without becoming appreciably blackened.

Colonel Dulier's apparatus is in use at the City Saw Mills, Glasgow, and at Messrs. Merryweather's factory at Greenwich, and is being fitted to the Opera in Paris. At Messrs. Merryweather's the smoke from 11 forges is collected in one main flue, and after being mixed with steam is subjected to the action of three water jets consuming 100 galls. of water an hour. The system is here found so satisfactory that the rest of the forges are shortly to be connected, and it is considered that the same amount of water will be sufficient to treat the smoke from them also. From observations made by the Public Analyst of Glasgow at the Saw Mills, it appears that the apparatus there removes over 90 per cent. of the solid matter of the smoke and more than half the sulphurous acid. It does not affect the draft in the chimney, any loss caused by the bends of the flues being compensated by the effects of the jet of steam which damps the smoke. In Glasgow this jet is at a pressure of 80 lbs. to 100 lbs. per square inch, but though a fairly high pressure both for the steam and water jets seems to be advantageous, yet it is not necessary. The apparatus has been fitted to a stack of chimneys in a house in Belgravia, and has worked satisfactorily, using the water from the mains, and the steam given off by an ordinary high-pressure hot-water boiler. It is even said to have resulted in a reduction in the amount of coal burnt. There is an incidental advantage connected with it which may commend itself to people who are solicitous about sanitation. The water which has been used in the flue contains a quantity of sulphurous acid, and is, therefore, a disinfectant of considerable power. The cost of construction ought not to be very great, since the flues are only large steel tubes. But if the apparatus fulfils all that is claimed for it, manufacturers might find themselves recouped for their outlay by being able to burn an inferior and cheaper coal without producing an improper amount of smoke.

Trials and Performance of French Warships.—A correspondent of the London *Times* writes: "Toward the close of last year French dockyards had to report very unsatisfactory results given by certain warships at their trials. The armored cruiser *Latouche-Tréville*—in the performances of which considerable interest is felt because she is fitted with Belleville boilers—had failed to develop the H.P. expected, the *Dupuy de Lôme* was still giving much trouble, and the *Fleurus* stood in need of considerable repairs after her mishaps. In contrast to this disappointing state of things is the series of successful trials more recently made. Some of the trouble given by the *Latouche-Tréville* is probably due to the fact that, like her sisters, the *Bruix*, *Chanzy* and *Charner*, she has been built upon a displacement (4,660 tons) too near the *minimum* for her offensive and defensive power; but she is a splendid cruiser, and will attract attention during the summer campaign of the northern squadron. With 7,400 H.P. she attained in February a speed of 17.5 knots; but when 8,450 H.P. was developed in the first official trials she steamed at 18.16 knots under the easiest conditions. The cruiser *Dupuy de Lôme* (6,600 tons), after her long series of mishaps, completed her trials at Brest early in April, attaining the high mean speed of 19.8 knots. The *maximum* rate was 20.4 knots, and it seems likely that 20 knots would have been maintained save for the inefficient stoking of one of the boilers. The mean revolutions of the middle screw were 135, and of the lateral screws 139. The *Dupuy de Lôme*, with her practically complete coating of armor, will certainly be one of the most remarkable vessels present at the opening of the North Sea and Baltic Canal. Another cruiser which has given very satisfactory results in March is the *Friane*, a protected vessel of 3,772 tons, built at Brest under the direction of M. Dugi de Bernonville. Her machinery has been constructed by the Forges et Chantiers de la Méditerranée, and the boilers, upon the Niclausse water-tube principle, are from the works of the company so named. The advantage

claimed for this system is that it enables the tubes to be reached easily. The mean speed in a rough sea was 18.8 knots, but during some runs a speed of 19.3 knots was attained and 9,503 H.P. was developed instead of the contract pressure of 9,000 H.P. The coal consumption also was small. The *Valmy*, coast-defence armorclad (6,590 tons), and sister of the *Jemmappes*, is giving satisfactory results at Brest, where, during a two-hours' forced draft run, she attained a mean speed of 16.71 knots at the end of March. Another sister, the *Bouvines*, has also entered upon her trials with great promise. These are the three armorclads which are to constitute such a powerful fighting unit in the northern squadron, and, as Admiral Besnard has told both the Chamber and the Senate, they are well fitted for the use of the ram by reason of their small turning circles and powerful build. Another vessel which has just attained a satisfactory trial speed (mean of 27 knots) at Brest is the sea-going torpedo-boat *Lansquenet;* but the bottom of one of her cylinders, as had been foreseen, gave way, and she returned to port for repairs."

Water-tube Boilers in the British Navy.—The following brief abstract, which was published in *The Times*, of a discussion of a paper on The Machinery of War Ships, by Mr. A. J. Durston, which was read before the Institute of Civil Engineers, will be of interest to many of our readers.

The point in the paper which perhaps attracted most attention was the introduction of water-tube boilers of different types into some of the ships built under the Naval Defence Act. Sir Edward Reed remarked that the paper contained the cream of the present knowledge of this type of boiler. Mr. Thorneycroft contended that in them was the best chance of reducing the weight of the propelling machinery of ships and of obtaining speed with lightness. It was impossible, he thought, to do much more than has already been done in reducing the weight of the engines, while we had, perhaps, sacrificed a little too much in the way of fuel. But real advance might be made in the boilers. Both the forms of tank boiler now in use—the locomotive and the drum—were heavy, and the paper contained evidence that they had been worked to their limit. The Belleville boiler, as fitted in the *Sharpshooter*, was a step in the right direction, but was still too heavy. He proceeded to give some figures concerning the weights and heating surfaces of the different types of boiler, showing that water-tube boilers weighed much less per square foot of heating surface than drum or locomotive boilers. Mr. Seaton pointed out that water-tube boilers would stand rough usage without sustaining the damage to which tank boilers would be liable. In war it would sometimes be necessary to get up steam quickly, and there would be no time for the "nursing" required by tank boilers. But steam could be got up very quickly in water-tube boilers without injury to them. As regards forced draft, Mr. Thorneycroft considered the last-mentioned type to be superior to drum boilers, which, sooner or later, he said, gave out under it. For short voyages at high speed he held that forced draft was essential, though for long voyages he believed in ample heating surfaces and no forced draft. The question of forced against induced draft was also discussed. Some speakers believed there was a future for induced draft, while others could not see that it makes much difference whether air is blown in at one end of the furnace or sucked out at the other. The air-pumps in all the new boats are worked off the main engines, and it was suggested that independent air-pumps (which had been tried in the United States Navy) would be an improvement. Mr. Seaton was strongly opposed to them. In the first place, they took up too much room, and, in the second, were the most difficult of all pumps to control. Sir Edward Reed inquired about the difference he observed between the ratios of the high and low pressure cylinders in the Navy and the mercantile marine. Mr. Durston, in reply, pointed out that warships had often to run for long periods at low power, and it was believed that a small ratio between the cylinders in such cases produced the most economical results. With regard to the variety of practice observable in the construction of engines and boilers in different ships, Mr. W. H. White remarked that these vessels were built by private firms who, while subject to certain general conditions laid down by the Admiralty, yet had a free hand in many points. Mercantile practice and naval practice reacted on each other to the advantage of both; an example might be found in the effect which the adoption of forced draft in the Navy had had on mercantile practice. In criticising warships it must always be borne in mind that they are made to be fighting machines, and that everything in them must be subordinated to that function. Mr. White also asked critics to believe that for every arrangement carried out in them there was a reason of some kind, and that nothing was done merely from "cussedness" on the part of the designers and engineers.

THE TEHUANTEPEC RAILROAD—ITS IMPORTANCE AS A COMPETITOR FOR TRANSCONTINENTAL TRAFFIC.

To the Editor of THE AMERICAN ENGINEER:

The announcement received some few days ago by cablegram from Mexico, that Congress has approved and ratified the contract made by the Executive Government with Messrs. Samuel Hermanos, of Mexico and New York, for the furnishing of $2,000,000 worth of rolling stock, bridges, lighters, tugs, and other equipment for the Tehuantepec Railroad, calls attention once more to the great problem of curtailing the time required for the transportation of passengers and freight between the principal commercial cities of the Eastern and Western Hemispheres.

The present century has been very prolific of schemes for transforming the physical character of certain portions of the universe, with the sole object of bringing together remote regions of the globe, the intimacy of whose commercial relations has been much handicapped by the lack of facilities for rapid transportation. It is only necessary to refer to some of the great engineering enterprises, such as the Suez Canal, the ill-fated Panama Canal, the projected Nicaragua Canal, the transformation of the Isthmus of Corinth into an ocean waterway; the conversion of the great manufacturing emporium of Manchester into a seaport town; and, at more recent date, the completion of the great ship canal in the Baltic Sea, and last, but not least, the completion of the Tehuantepec Railroad, after so many years of vicissitudes, to realize at once the vastly important *rôle* which the question of rapid transportation plays in the development of international commerce.

The Tehuantepec Railroad has met with so many misadventures, has had to struggle so frequently with financial difficulties, and has suffered such protracted delays in its final completion, that the real significance of its bearing upon the future of international commerce, while so thoroughly realized by its original projectors and by the Mexican nation, has not awakened in the minds of the present generation the interest to which its importance entitles it, principally because the quiet and unpretentious way in which its completion has been brought about has hidden its light behind a bushel, so to speak, and the outside world of the present day has been quite unconscious of the potentialities which are now about to be laid bare by the entry of the Tehuantepec Railroad into the field of international transportation.

The circumstances surrounding this achievement, and the innumerable vicissitudes through which it has passed, make very interesting reading to those who are inspired by the story of great commercial and financial enterprises, and, when the last page of its history has been written, the whole volume will be found to contain much that furnishes an eloquent tribute to the masterful genius, political sagacity, and patriotic perseverance of General Perfirio Diaz and those of his official associates into whose hands have been confided the destinies of Mexico during the past fifteen years.

The present generation, however, is most deeply concerned with its importance as a commercial enterprise, and, in this connection, it will suffice to refer to the following table, compiled from the Board of Trade returns of the Foreign Commerce and Navigation Section of the United States Treasury, showing the comparative distance between some of the principal of the world's shipping ports by way of Panama and the Tehuantepec route respectively:

	Via Tehuantepec R. R.	Via Panama R. R.
	Miles.	Miles.
New York & Hong Kong	11,597	11,645
" " " Auckland	9,345	9,313
" " " Melbourne	11,068	11,471
" " " Honolulu	6,566	7,705
" " " San Francisco	4,925	6,107
Liverpool " " "	8,274	9,071
New Orleans " "	3,561	5,415
" " & Auckland	7,981	9,426
" " " Honolulu	5,202	7,182
Liverpool & Yokohama	13,224	14,175
" " Melbourne	14,113	14,435
" " Auckland	12,584	12,777
" " Honolulu	9,805	10,670

In short, if a comparison is made with the Tehuantepec Railroad on 16 of the main routes of commerce between the East and the West, it will be found that the total saving by this route is over 125,000 miles.

It is understood that Messrs. Samuel Hermanos, who have so successfully carried through the contract above referred to, are likewise negotiating for the work of dredging the ter-

minal harbors at Coatzacoalcos and Salina Cruz, and constructing wharves and jetties on each side of the coast. As the work to be accomplished is one which is peculiarly fitted to the structural genius and enterprise of many well-known contractors of this country, and there is, we are informed, a good opportunity for much if not all of this work to be carried out with American capital and American enterprise on a very remunerative basis, it will doubtless be interesting to many of our readers to learn briefly the character of the work to be accomplished; and the conditions that have to be dealt with.

Mr. Corthell, an eminent engineer, who was closely identified with the construction of the Tehuantepec Railroad during its final stages, under the supervision of the Mexican Government, and who has had many opportunities of thoroughly investigating the important works yet to be accomplished, contributed some time ago a very interesting article to the *Engineering Magazine*, of New York, and we acknowledge our indebtedness to this article for some of the data furnished herein.

The route across the neck of land known as the Isthmus of Tehuantepec is very much shorter than that by the Isthmus of Panama, and lies through a country possessing a good climate and very encouraging prospects of a profitable local traffic. The physical character of the country traversed by the line is somewhat varied, being very level in some points, and in others very mountainous. In the mountainous regions the maximum grade does not exceed 2 per cent., while that on the tableland, running through an ordinary rolling country, does not exceed 1.8 per cent.

Five large rivers, of much importance to the surrounding country both for irrigation and navigation purposes, are traversed by the line, and there is only one tunnel, about 300 ft. in length. The line has been well and solidly laid, on a good roadbed.

The equipment now being built will furnish the necessary facilities for handling a vast amount of transcontinental traffic, and the realization of this project will be fully and finally accomplished when the harbor works, to which the above-mentioned contract has reference, shall have been brought to a satisfactory conclusion.

The terminus of the Gulf Coast is at the mouth of the Coatzacoalcos River, having a watershed area of about 6,500 square miles. The river enters the Gulf between two headlands, one composed of sand-dunes, and the other of solid rocks about 60 ft. high. The bar at the mouth of the river is an obstruction at the present time to the crossing of vessels drawing more than 11½ or 12 ft. of water, but the continued flow of fresh water excavates a deep channel through this bar at the present time.

The Engineering Department of the Mexican Government has laid out various projects from time to time, and is even now at work upon a final scheme, the result of the last survey made by very competent engineers. It is possible that the final plans will not differ materially from those which have been set forth up to date, and the following particulars will convey a very accurate idea of what is to be accomplished.

On the Gulf Coast it is proposed to build parallel jetties extending 4,500 ft. from the shore to about 34 ft. deep in the Gulf, with a distance between the two jetties of about 800 ft. The permanent structures are to be built entirely of rock.

The considerations upon which these plans have been based have been largely determined by the fact that there is a constant sea current with a velocity of from 1 to 3 miles an hour entering the Gulf of Mexico between the peninsular of Yucatan and the island of Cuba. This current hugs the coast-line, so to speak, throughout the whole extent of the mainland, past the mouth of the Coatzacoalcos River, Vera Cruz, and Tampico, and the concave configuration of this coast-line intensifies somewhat the effect of the current upon all of the Gulf harbors and riverways.

It is proposed to build a wharf parallel to the shore, and running a distance of about 2,000 ft., either of creosoted timber, or of piles, or of steel. In consequence of the steep slope of the bank, this wharf need not be more than 100 ft. wide from the shore-line in order to run into deep water.

The equipment contract, above referred to, includes the furnishing of the necessary tracks, warehouses, and complete hydraulic plant for handling freight quickly and economically from the vessels to the cars.

The structural work to be built on the Pacific coast is somewhat different in character, and consists mainly of a breakwater of broken stone, coped with concrete blocks. The question of dredging does not enter on this side, because the slope of the shore under water is quite steep, and there is at all times considerable depth of water. What is mainly required is the construction of a protected and quiet harbor, to enable ships of all sizes to anchor under the most tempestuous conditions and during the prevalence of the strong winter northers.

It is estimated that the jetties and auxiliary works in Coatzacoalcos Harbor will cost about $2,250,000, and the proposed terminal wharf, with its warehouses, tracks, and hydraulic plant, will cost about $360,000. The estimate of expenses of the Salina Cruz works, comprising the breakwater terminal piers and dredging, will amount to about $3,085,000, making a total for both harbors and terminal works of $5,695,000 gold.

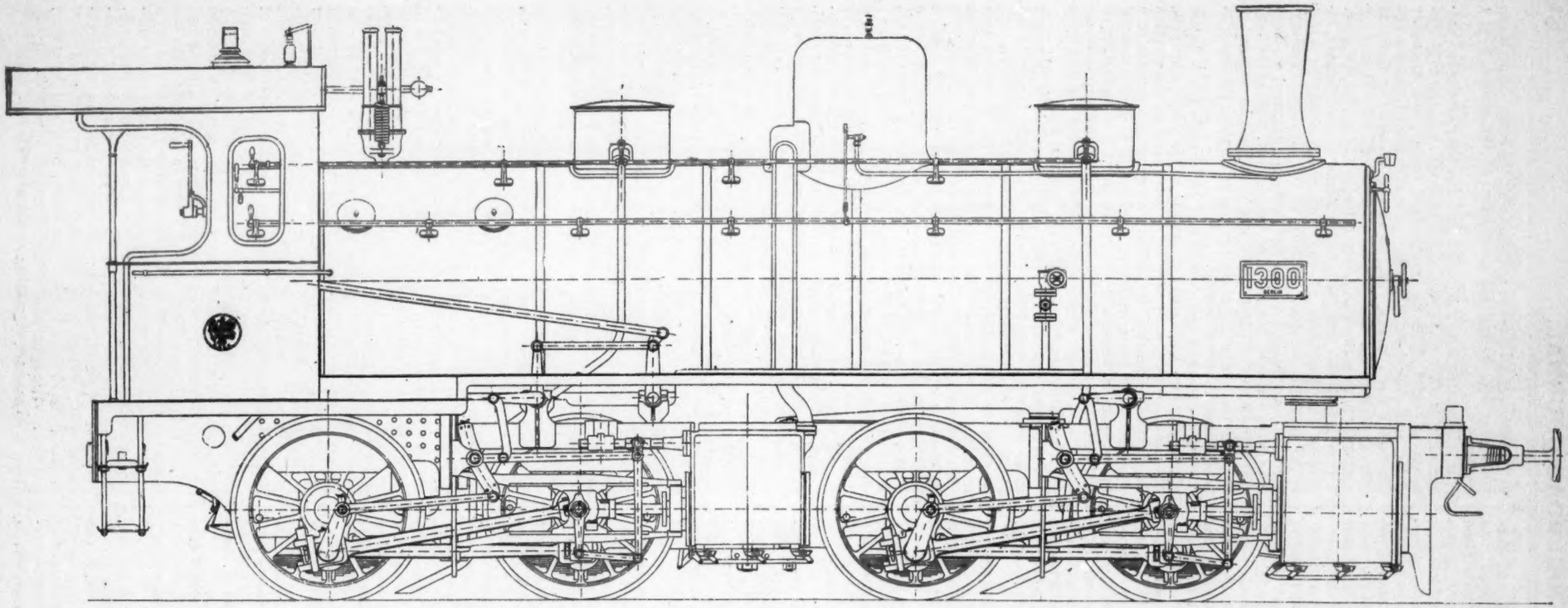
It is understood that the general terms of the contract, including the conditions of payment, while reflecting great credit upon the financial stability of the Mexican Treasury, and the broad-minded and comprehensive judgment of those who have outlined the basis of the project, will prove very remunerative to all parties who will ultimately be engaged in carrying the works to completion and liquidating the financial transactions involved therein.

British financiers and contractors are usually much better equipped from the outset to tackle these large contracts, because they are always safe to proceed upon the assumption that all such undertakings, if they contain the elements of a substantial and remunerative enterprise, will at once command the support of financial institutions, and the co-operation of contractors to meet all legitimate and reasonable requirements needed by a country whose material development depends upon the fructifying assistance of foreign financial aid.

The general ignorance prevailing in this country with regard to the important *rôle* which Mexico is destined to play in the battle for commercial supremacy, and more particularly the true inward significance of the possession by Mexico of this important key to traffic between the Eastern and Western Hemispheres, is largely responsible for the supineness and indifference of financial institutions in this country toward lending their aid to the development of its important public works. It is time that the people of the United States should realize that Mexico is a country of vast natural resources, which absorb the investment of foreign capital only to return it tenfold, and that it is no longer a sign of great astuteness to regard Mexico as a country always on the brink of a revolutionary volcano, but rather a sign of the most crass and obstinate stupidity to blind one's eyes to the fact that fifteen years of absolute political tranquillity, the construction of 12,000 miles of railroad, of 20,000 miles of telegraph lines, and the development of vast industrial enterprises, as much with American as with native and European capital, have planted, so to speak, at the door of every inhabitant of the country, a material interest which makes for peace and the tranquillity required for industrial and commercial development, and has annihilated altogether these negative conditions wherein revolutionary outbreaks might have been regarded as a species of Pandora's box, full of encouragement to the disaffected elements that were rampant before the development of the political and industrial development of the country had given them that which they required to ally themselves closely with the nation's prosperity.

The present significance of the Tehuantepec Railroad can be seen in the effect which it will have upon the trade with the European nations and the Pacific coast-line of America, as well as between the United States and Asiatic ports, and the nature of this effect is amply demonstrated by a consideration of the time required for freight by various routes which have been thoroughly investigated with the following results:

Transportation from San Francisco by fast freight line to New York *via* Southern Pacific to New Orleans, and thence by water to New York, covering a distance of about 9,286 miles, is accomplished in 14 days. It takes 140 days to cover by sail the distance of 15,420 miles around Cape Horn; 60 days by steam along a route of 13,000 miles *via* the Straits of Magellan; 25 days *via* Transcontinental line fast freight over a distance of 10,203 miles, and only 20 days *via* the Tehuantepec Railroad, a distance of 4,280 miles. A comparison of the time and distance of all rail routes by the time and distance of half rail and half ocean routes *via* New Orleans, at once demonstrates the importance of this new Tehuantepec route as a competitor for the class of traffic, for it is mainly on account of the facts brought out by this comparison, and of the absence of the Tehuantepec Railroad as a factor in this trade, that the Southern Pacific and Morgan Line *via* New Orleans has been able to obtain from 75 to 90 per cent. of the entire transcontinental traffic, and dictate their own terms to competing lines. There is very little doubt that the great advantages of a geographical, physical, nautical, and commercial character possessed by the Tehuantepec Railroad route over those of Cape of Good Hope, Suez Canal, Cape Horn, Straits of Magellan, Panama, Nicaragua, and Transcontinental Line will rapidly divert a large share of existing traffic over this new line.



SIDE ELEVATION OF EIGHT-WHEELED COMPOUND LOCOMOTIVE FOR THE PRUSSIAN STATE RAILWAYS.

EIGHT-WHEELED COMPOUND FREIGHT LOCOMOTIVE FOR THE PRUSSIAN STATES RAILROADS WITH FRONT STEAM-TRUCK.

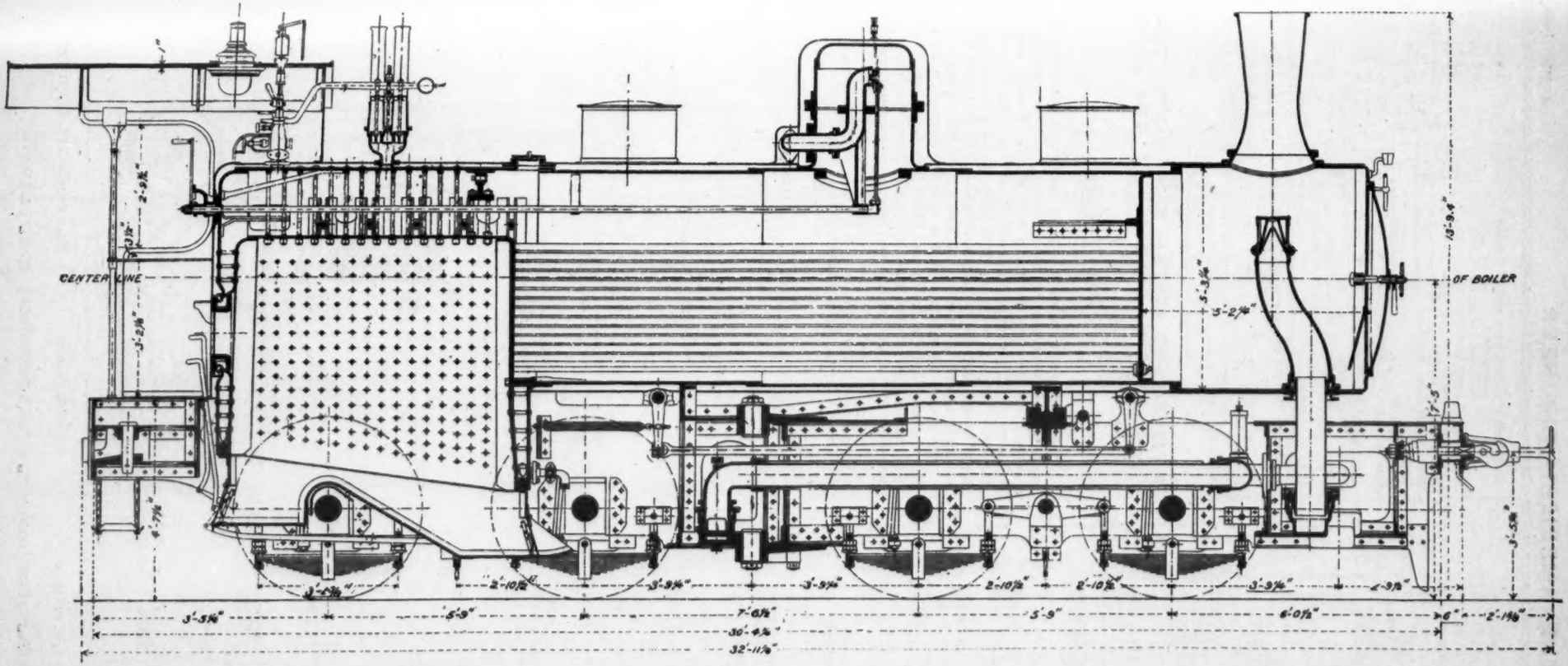
WE reproduce from a recent issue of *Glaser's Annalen* the engravings of an adaptation of the Fairley type of locomotive that is now in use on the Prussian State Railroads. As will be seen from the illustrations, the locomotive is carried upon eight wheels coupled in sets of four, and each set driven by a separate set of engines. Those at the back, which are in the rigid portion of the frame, are driven by a pair of high-pressure cylinders 15¾ in. in diameter and 23.6 in. stroke. As these cylinders are rigidly fastened to the boiler, steam is brought to them directly from the dome by pipes coming down on the outside of the boiler lagging, and which branch out from the stand-pipe immediately back of the dome.

The front set of four drivers with the low-pressure cylinders are carried on a Bissell type of truck that is pivoted midway between the forward drivers of the back set and the back drivers of the forward set, with a sliding bearing against the bottom of the boiler midway between the two forward pairs of drivers.

The exhaust-pipe from the high-pressure cylinders is pivoted in a stuffing-box just back of the pivot-pin of the truck, and the inequalities in distance between this point and the forward cylinders, due to the distance between centres, is compensated for by an expansion joint at the front end of the exhaust-pipe or receiver by using an ordinary stuffing-box at this point. The low pressure cylinders have a diameter of 23⅝ in., and a stroke of 23.6 in. Thus the relative area of the two sets of cylinders is as 1 to 2¼.

The stationary link is used to move the valves of the two sets of cylinders, both being operated by a single reach-rod controlled by the usual screw-reversing motion in the cab. The main reach-rod extends from the cab to an arm on a shaft just back of the cylinders. From this arm a short connection is made back to the lifting shaft lever of the high-pressure cylinders, while from an arm projecting downward from the auxiliary lifting-shaft a supplementary reach-rod extends forward along the centre line of the engine to the arm of the low-pressure lifting-shaft, as shown in the longitudinal section of the engine.

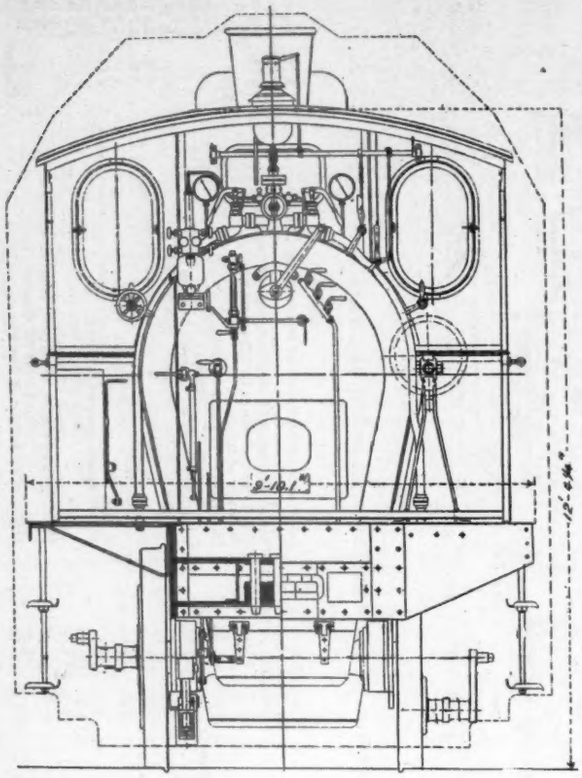
Referring to the cross-sections through the cylinders, the course of the steam from the dome to the stack can be very easily followed. As we have already said, it comes down on the outside of the boiler to the high-pressure steam-chests. The exhausts from these cylinders drop down to a point about on a level with the lower sides of their shells and at the centre of the boiler, whence it rises and passes through a long receiver pipe, as noted, to the low-pressure steam-chests. The exhaust from these cylinders also drops down quite low to allow for the introduction of a pipe to compensate for the side motion of the truck, and deliver the steam into a long blast-pipe in the smoke-box. In other respects the engine is fitted and equipped similar to the other engines of the Prussian State Railways.



LONGITUDINAL SECTION OF EIGHT-WHEELED COMPOUND FREIGHT LOCOMOTIVE FOR THE PRUSSIAN STATE RAILWAYS.

The following are some of the principal dimensions of this locomotive :

Weight upon the back H.P. driver springs in working order	24,250 lbs.
Weight of back H.P. drivers, axle and attachments	5,512 lbs.
Total weight upon back H.P. driving-wheel tires in working order	29,762 lbs.
Weight upon forward H.P. driver springs in working order	24,833.3 lbs.
Weight of forward H.P. drivers, axle, and attachments	5,370.2 lbs.
Total weight on tires of forward H.P. drivers in working order	30,193.5 lbs.
Weight upon back L.P. driver springs in working order	25,242.2 lbs.
" of " " drivers, axle, and attachments	5,512 lbs.
Total weight on tires of back L.P. drivers in working order	30,754.2 lbs.
Weight upon forward driver springs in working order	25,947 lbs.
" of forward drivers, axle, and attachments	5,258.15 lbs.
Total weight on forward driver tires	31,205.15 lbs.
" " of locomotive in working order	121,914.85 lbs.
" " " empty	106,902 lbs.
" wheel base	5 ft. 9 in.
Distance between centres of L.P. drivers	5 ft. 9 in.
" " " H.P. "	3 ft. 9¼ in.
Distance from centre of L.P. cylinders to centre of forward drivers	8 ft. 9¼ in.
Distance from centre of H.P. cylinders to centre of forward pair of H.P. drivers	2 ft. 4½ in.
Transverse distance between H.P. cylinder centres	6 ft. 9½ in.
" " L.P. " "	6 ft. 9½ in.
Diameter of H.P. cylinder	15¾ in.
Stroke of H.P. piston	1 ft. 11.6 in.
Diameter of L.P. cylinder	1 ft. 11⅝ in.
Stroke of L.P. piston	1 ft. 11.6 in.
Diameter of driving-wheels outside of tires	4 ft. 1¾ in.
" " axle journals	7½ in.
" " wheel seat	7½ in.
Length of springs, centre to centre of hangers	3 ft. 1⅛ in.
Boiler	Straight top.
Inside diameter of smallest ring of barrel	4 ft. 9⅝ in.
Thickness of plates in barrel of boiler	0.7 in.
Number of tubes	218
Diameter of tubes, outside	2 in.
" " " inside	1.8 in.
Distance between centres of tubes	2.6 in.
Length of tubes between tube plates	14 ft. 1.3 in.
" " fire-box	6 ft. 2.8 in.
Depth " " front	5 ft. 9.7 in.
" " " back	4 ft. 11.8 in.
Width " " top	3 ft. 7.3 in.
Water space, side of fire-box	2¾ in.
" " back of fire-box	4.9 in.
" " front of fire-box	2¾ in.
Thickness of plates of outside shell of fire-box	⅜ in.
" " side plates of fire-box	⅝ in.
Material of inside of fire box	Copper.



REAR ELEVATION SHOWING CLEARANCES.

Thickness of plates, back end of fire-box	0.6 in.
" " crown-sheet	⅝ in.
" " back head of boiler	0.7 in.
" " front tube-sheet	1 in.
" " back	1.1 in.
Crown sheet stayed	By vertical stays.
Diameter of dome, inside	2 ft. 9 in.
Height " " "	2 ft. 10⅝ in.
Grate surface	20.9 sq. ft.
Heating surface in fire-box	108.7 sq. ft.
" " " tubes	1,456.4 sq. ft.
Total heating surface	1,565.1 sq. ft.
Kind of blast nozzle	Single.
Height from top of rails to top of stack	13 ft. 9.4 in.
" " " " " centre of boiler	7 ft. 5 in.
Kind of frame	Plate.
Distance between insides of frames	4 ft. 0.2 in.
Transverse distance between valve stems	7 ft. 8 in.
" " " side rods	5 ft. 10 in.
Width of engine over all	9 ft. 10.1 in.
Height of top of cab above rails	12 ft. 4¼ in.
" " foot plate above the top of the rails	4 ft. 7½ in.
Width of tires over all	5.5 in.

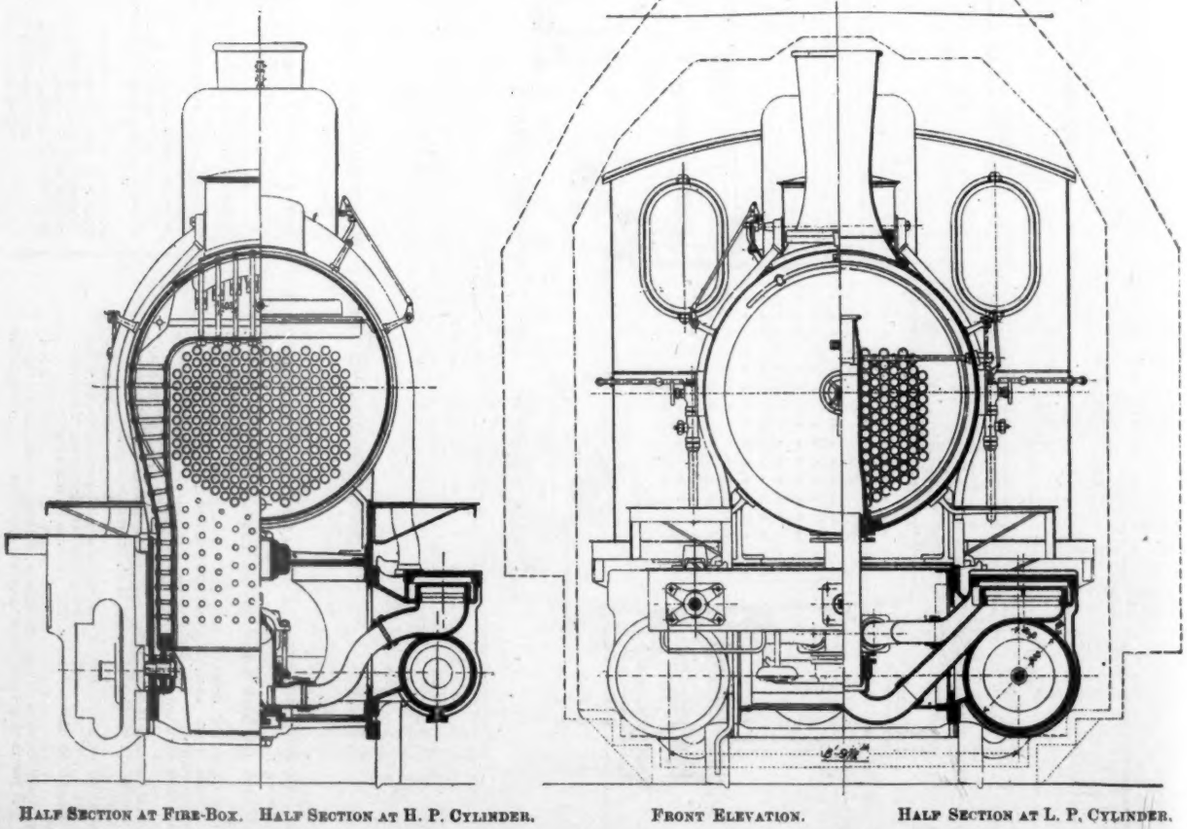
A PIECE-RATE SYSTEM, BEING A STEP TOWARD PARTIAL SOLUTION OF THE LABOR PROBLEM.*

BY FRED. W. TAYLOR.

THE ordinary piece-work system involves a permanent antagonism between employers and men, and a certainty of punishment for each workman who reaches a high rate of efficiency. The demoralizing effect of this system is most serious. Under it, even the best workmen are forced continually to act the part of hypocrites, to hold their own in the struggle against the encroachments of their employers.

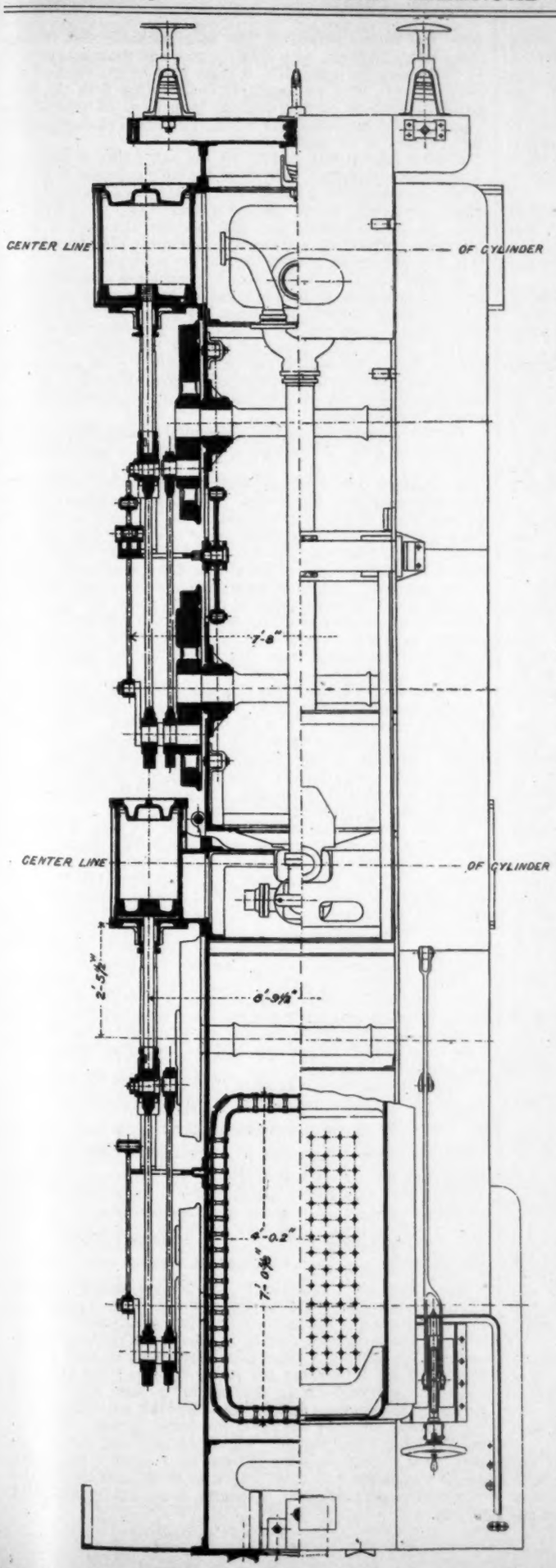
The system introduced by the writer, however, is directly the opposite, both in theory and in its results. It makes each workman's interests the same as that of his employer, pays a premium for high efficiency, and soon convinces each man that

* Extracts from a paper presented at the Detroit meeting (June, 1895) of the American Society of Mechanical Engineers.



HALF SECTION AT FIRE-BOX. HALF SECTION AT H. P. CYLINDER. FRONT ELEVATION. HALF SECTION AT L. P. CYLINDER.

EIGHT-WHEELED COMPOUND FREIGHT LOCOMOTIVE FOR THE PRUSSIAN STATE RAILWAYS.



HALF PLAN AND HORIZONTAL SECTION OF EIGHT-WHEELED COMPOUND LOCOMOTIVE ON THE PRUSSIAN STATE RAILWAYS.

it is for his permanent advantage to turn out each day the best quality and maximum quantity of work.

The writer has endeavored in the following pages to describe the system of management introduced by him in the works of the Midvale Steel Company, of Philadelphia, which has been employed by them during the past ten years with the most satisfactory results.

The system consists of three principal elements:

1. An elementary rate-fixing department.
2. The differential rate system of piece-work.
3. What he believes to be the best method of managing men who work by the day.

The differential system of piece-work consists briefly in offering two different rates for the same job: a high price per piece, in case the work is finished in the shortest possible time and in perfect condition; and a low price, if it takes a longer time to do the job, or if there are any imperfections in the work. (The high rate should be such that the workman can earn more per day than is usually paid in similar establishments.) This is directly the opposite of the ordinary plan of piece-work, in which the wages of the workmen are reduced when they increase their productivity.

The advantages of this system of management are:

1. That the manufactures are produced cheaper under it, while at the same time the workmen earn higher wages than are usually paid.

2. Since the rate-fixing is done from accurate knowledge, instead of more or less by guess-work, the motive for holding back on work, or "soldiering," and endeavoring to deceive the employers as to the time required to do work, is entirely removed, and with it the greatest cause for hard feelings and war between the management and the men.

3. Since the basis from which piece-work, as well as day-rates, are fixed is that of exact observation, instead of being founded upon accident or deception, as is too frequently the case under ordinary systems, the men are treated with greater uniformity and justice, and respond by doing more and better work.

4. It is for the common interest of both the management and the men to co-operate in every way, so as to turn out each day the maximum quantity and best quality of work.

5. The system is rapid, while other systems are slow, in attaining the maximum productivity of each machine and man; and when this maximum is once reached, it is automatically maintained by the differential rate.

6. It automatically selects and attracts the best men for each class of work, and it develops many first-class men who would otherwise remain slow or inaccurate, while at the same time it discourages and sifts out men who are incurably lazy or inferior.

Finally, one of the chief advantages derived from the above effects of the system is, that it promotes a most friendly feeling between the men and their employers, and so renders labor unions and strikes unnecessary.

It is the opinion of the writer that the basis for harmonious co-operation lies in the two following facts:

1. *That the workmen in nearly every trade can and will materially increase their present output per day, providing they are assured of a permanent and larger return for their time than they have heretofore received.*

2. *That the employers can well afford to pay higher wages per piece even permanently, providing each man and machine in the establishment turns out a proportionately larger amount of work.*

The truth of the latter statement arises from the well-recognized fact that, in most lines of manufacture, the indirect expenses equal or exceed the wages paid directly to the workmen, and that these expenses remain approximately constant, whether the output of the establishment is great or small.

From this it follows that it is always cheaper to pay higher wages to the workmen when the output is proportionately increased; the dimin-

ution in the indirect portion of the cost per piece being greater than the increase in wages. Many manufacturers, in considering the cost of production, fail to realize the effect that the *volume of output has on the cost*. They lose sight of the fact that taxes, insurance, depreciation, rent, interest, salaries, office expenses, miscellaneous labor, sales expenses, and frequently the cost of power (which in the aggregate amount to as much as wages paid to workmen), remain about the same whether the output of the establishment is great or small.

The means which the writer has found to be by far the most effective in obtaining the maximum output of a shop, and which, so far as he can see, satisfies the legitimate requirements, both of the men and the management, is the *differential rate system of piece-work*.

This consists briefly in paying a higher price per piece, or per unit, or per job, if the work is done in the shortest possible time, and without imperfections, than is paid if the work takes a longer time or is imperfectly done.

To illustrate: Suppose 20 units or pieces to be the largest amount of work of a certain kind that can be done in a day. Under the differential rate system, if a workman finishes 20 pieces per day, and all of these pieces are perfect, he receives, say, 15 cents per piece, making his pay for the day $15 \times 20 =$ \$3. If, however, he works too slowly and turns out, say, only 19 pieces, then, instead of receiving 15 cents per piece he gets only 12 cents per piece, making his pay for the day $12 \times 19 =$ \$2 28, instead of \$3 per day.

If he succeeds in finishing 20 pieces, some of which are imperfect, then he should receive a still lower rate of pay, say, 10 cents or 5 cents per piece, according to circumstances, making his pay for the day \$2, or only \$1, instead of \$3.

It will be observed that this style of piece-work is directly the opposite of the ordinary plan. To make the difference between the two methods more clear; supposing, under the ordinary system of piece work, that the workman has been turning out 16 pieces per day, and has received 15 cents per piece, then his day's wages would be $15 \times 16 =$ \$2.40 Through extra exertion he succeeds in increasing his output to 20 pieces per day, and thereby increases his pay to $15 \times 20 =$ \$3. The employer, under the old system, however, concludes that \$3 is too much for the man to earn per day, since other men are only getting from \$2.25 to \$2.50, and therefore cuts the price from 15 cents per piece to 12 cents, and the man finds himself working at a more rapid pace, and yet earning only the same old wages, $12 \times 20 =$ \$2.40 per day. What wonder that men do not care to repeat this performance many times?

As far as possible each man's work should be inspected and measured separately, and his pay and losses should depend upon his individual efforts alone. It is, of course, a necessity that much of the work of manufacturing—such, for instance, as running roll-trains, hammers, or paper machines—should be done by gangs of men who co-operate to turn out a common product, and that each gang of men should be paid a definite price for the work turned out, just as if they were a single man.

In the distribution of the earnings of a gang among its members, the percentage which each man receives should, however, depend not only upon the kind of work which each man performs, but upon the accuracy and energy with which he fills his position.

In this way the personal ambition of each of a gang of men may be given its proper scope.

Again, we find the differential rate acting as a most powerful lever to force each man in a gang of workmen to do his best; since if, through the carelessness or laziness of any one man, the gang fails to earn its high rate, the drone will surely be obliged by his companions to do his best the next time or else get out.

A great advantage of the differential rate system is that it quickly drives away all inferior workmen, and attracts the men best suited to the class of work to which it is applied; since none but really good men can work fast enough and accurately enough to earn the high rate; and the low rate should be made so small as to be unattractive even to an inferior man.

If for no other reason than it secures to an establishment a quick and active set of workmen, the differential rate is a valuable aid, since men are largely creatures of habit; and if the piece-workers of a place are forced to move quickly and work hard the day-workers soon get into the same way, and the whole shop takes on a more rapid pace.

The system of differential rates was first applied by the writer to a part of the work in the machine shop of the Midvale Steel Company, in 1884. Its effect in increasing and then maintaining the output of each machine to which it was applied was almost immediate, and so remarkable that it soon came into high favor, with both the men and the management. It was gradually applied to a great part of the work of the establishment, with the result, in combination with the rate-fixing department, of doubling and in many cases trebling the output, and at the same time increasing instead of diminishing the accuracy of the work.

In some cases it was applied by the rate-fixing department without an elementary analysis of the time required to do the work; simply offering a higher price per piece providing the maximum output before attained was increased to a given extent. Even this system met with success, although it is by no means correct, since there is no certainty that the reward is in just proportion to the efforts of the workmen.

In cases where large and expensive machines are used, such as paper machines, steam hammers, or rolling mills, in which a large output is dependent upon the severe manual labor as well as the skill of the workmen (while the chief cost of production lies in the expense of running the machines rather than in the wages paid), it has been found of great advantage to establish two or three differential rates, offering a higher and higher price per piece or per ton as the maximum possible output is approached.

The first case in which the differential system was applied furnishes a good illustration of what can be accomplished by it.

A standard steel forging, many thousands of which are used each year, had for several years been turned at the rate of from four to five per day under the ordinary system of piece-work, 50 cents per piece being the price paid for the work. After analyzing the job and determining the shortest time required to do each of the elementary operations of which it was composed, and summing up the total, the writer became convinced that it was possible to turn ten pieces per day. To finish the forgings at this rate, however, the machinists were obliged to work at their maximum pace from morning to night, and the lathes were run as fast as the tools would allow, and under a heavy feed.

It will be appreciated that this was a big day's work, both for the men and the machines, when it is understood that it involved removing, with a single 16-in. lathe, having two saddles, an average of more than 800 lbs. of steel chips in ten hours. In place of the 50-cent rate that they had been paid before, they were given 35 cents per piece when they turned them at the speed of 10 per day, and when they produced less than 10, they received only 25 cents per piece.

It took considerable trouble to induce the men to turn at this high speed, since they did not at first fully appreciate that it was the intention of the firm to allow them to earn permanently at the rate of \$3.50 per day. But from the day they first turned 10 pieces to the present time, a period of more than ten years, the men who understood their work have scarcely failed a single day to turn at this rate. Throughout that time, until the beginning of the recent fall in the scale of wages throughout the country, the rate was not cut.

During this whole period the competitors of the company never succeeded in averaging over half of this production per lathe, although they knew and even saw what was being done at Midvale. They, however, did not allow their men to earn over from \$2 to \$2.50 per day, and so never even approached the maximum output.

The following table will show the economy of paying high wages under the differential rate in doing the above job:

COST OF PRODUCTION PER LATHE PER DAY.

Ordinary System of Piece-work.		Differential Rate System.	
Man's wages	\$2.50	Man's wages	\$3.50
Machine cost	3.37	Machine cost	3.37
Total cost per day	\$5.87	Total cost per day	\$6.87
Five pieces produced.		Ten pieces produced.	
Cost per piece	\$1.17	Cost per piece	\$0.69

The above result was mostly, though not entirely, due to the differential rate. The superior system of managing all of the small details of the shop counted for considerable.

There has never been a strike by men working under differential rates, although these rates have been applied at the Midvale Steel Works for the past ten years; and the steel business has proved during this period the most fruitful field for labor organizations and strikes. And this notwithstanding the Midvale Company has never prevented its men from joining any labor organization. All of the best men in the company saw clearly that the success of a labor organization meant the lowering of their wages, in order that the inferior men might earn more, and, of course, could not be persuaded to join.

THE USE OF COMPRESSED AIR IN FOUNDRIES.

At a meeting of the Foundrymen's Association, recently held in Philadelphia, a paper on this subject was read by Howard A. Pedrick. In it he pointed out that compressed air could be advantageously used in foundries for a variety of purposes. The air supplied should be dry, so that in exhausting from a hoist or other apparatus it does not cause a spray. For this reason cooling the air by means of a water-jacket around the compressing cylinder is preferable to allowing water to get into the cylinder and mingle with the air. The air receiver or reservoir should be of liberal size—not less than 4 ft. in diameter and 8 ft. long, although, doubtless, the size must depend to a great extent on the amount of work done in a foundry. The receiver should be capable of standing a pressure of 100 lbs. per square inch, should have a gauge to indicate the pressure, a safety-valve, drain-cock at the bottom for drawing off water, and an inlet-hole not less than 1¼ in. diameter. The outlet should be near the top, where the air is dryest. The conducting-pipe through the foundry should not be less than 1¼ in., and every connection should be a T. If the openings thus left are not used they can be plugged up, and it will be found a good plan to arrange the pipe line so that a connection can be made without trouble or expense.

Wire-wrapped ¾-in. hose, which is quite good enough and not expensive, is the best conveyor of air from the pipe line to the different fixtures. A hose long enough to serve quite a floor area will do better, and save much time employed to do work in which now the moulder uses his hand-bellows and brush. These fixtures are similar to the common garden hose branch pipes fitted with a thumb cock on them, and are easily controlled, and are not liable to be lost and are a great convenience.

Pneumatic hoists may also be used with great advantage for handling materials, flasks, etc. Such hoists are now commercial articles, and cost very little.

The general construction is a cylinder fitted with a piston and rod suspended from the top end, allowing the piston-rod to have the load attached to it. They are direct-acting, needing considerable height of floor for working them. The general mode of using them is to hang them from a fixed position. This does well enough for certain work, but the better and most practical way is to have them arranged on a trolley running on an overhead rail. A jib-arm, arranged to cover a sufficient floor area, makes a fixture which can be handled and utilized with very little energy, at the same time more speedy than a mechanically moved apparatus for loads varying from 100 to 10,000 lbs.

Large travelling cranes are capable of being worked with compressed air as a motive power with very good results. The only change from the electric or power-driven machine is the driving of its engines with air. Hand-power travelling cranes can be easily made into power cranes, and accomplish much saving by the substitution of air power.

The pneumatic system of lifting seems to be better adapted for the general run of work, ranging from that which is too heavy for one man to handle up to about 10,000 lbs. The hoist requires no manual labor other than the manipulation of a small three-way valve. The speed for lifting is variable, being entirely under the control of the operator, the workman not having to wait for slowly moving mechanism or for the shop laborers to lend him aid, vastly assisting him in his work and removing any impediment to his entire independence.

The writer appreciated the delicacy required to lift a cope or flask from the drag without injuring the mould. For this particular purpose he described a taper-winding drum for the lifting chains to wind on, thereby reducing the speed of the lifting chains at the start, and also having the effect of lowering down to slacken speed as the terminus is reached. In parting a flask, it is good in practice to allow the chains to have considerable slack in it. The operator then admits enough air to slowly start the winding drums, which, when the hoist encounters the frictional resistance offered, appear for an instant to cease lifting. Here it is that the elasticity of air plays its part, for after the apparent stop the hoist will gently strain on the chains until the power is enough to overcome the resistance, lifting the cope without damage to the mould, which can then be handled as rapidly as desired.

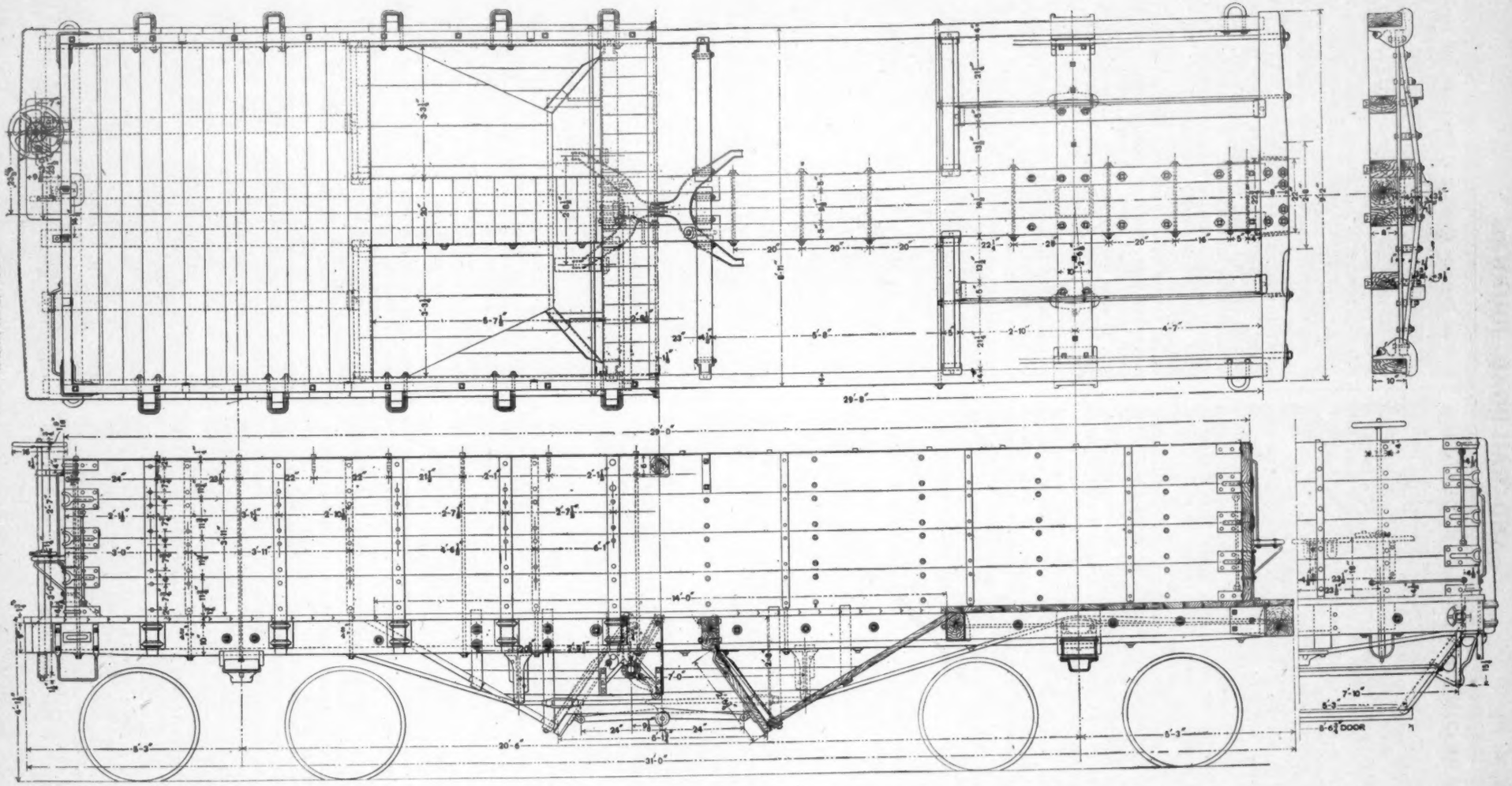
Those who use the foundry's product appreciate well-cleaned and good-looking castings, and are disposed to patronize a foundry looking well after this end of the business. Often they are willing to pay a higher price where attention is given to this point. Some few years ago the experiment of cleaning castings by the sand-blast process was tried, and some difficulties were encountered that caused it to fall short of the expectations of some of the experimenters. Steam at about 60 lbs. pressure was the force then used. It wet the sand, causing frequent clogging of the pipes, and made it next to impossible for a man to stand the severe rebound of the sand; but realizing the future the sand blast had before it, its promoters have perfected the apparatus by the use of compressed air. This now allows its use for bringing castings to a further degree of perfection, removing scale, and cleaning off in a thorough manner all the burnt-on sand in places which otherwise would be hard to reach. Ornamental and fancy castings can be thoroughly and cheaply treated in this way, producing an article which otherwise requires considerable labor to finish. In ordinary classes of work it is possible, and at the same time practical, to clean thoroughly 6 sq. ft. per minute, no matter how much ornamentation covers the casting. Steel castings are very hard to clean ordinarily, but yield under the influence of the sand blast. The machine used for supplying the sand is constructed in appearance like a vertical boiler, fitted with the necessary mechanism of feed-valves, sand chambers, etc., so arranged that an air pressure of about 10 lbs. per square inch catches the sand and delivers it through a pure rubber hose, which on moving about must not kink. A sharp bend would allow the sand, going at the velocity it does, to soon destroy the hose. A peculiar feature of the sand blast is that it only cares to attack hard substances. Anything of a soft or yielding nature will stand to a remarkable degree its cutting action. In practical operation the work is accomplished by handling the hose pointed at the object in the same manner as if playing water on it. In operation it creates considerable dust; to prevent this an open or well-ventilated place is preferable, as the dust then cannot become obnoxious. The machine is portable, and by conveying the air supply to it allows it to be used almost anywhere. The application of the sand blast does not find its full utility for foundry work in just the foregoing procedure. The writer's attention was called a short time ago to an ingenious contrivance in the nature of a tumbler or a rattler, revolving on frictionless rollers, with an attachment for the sand-blast nozzle. The action of the machine was the same as of that now used in the average foundry, except in having the sand blast applied to it, which appeared to possess much merit in more thoroughly cleaning the smaller pieces with less tumbling.

The pneumatic chisel will do vastly more and better work than several men can accomplish in the old way. This little tool will weigh about 15 or 20 lbs. It is a cylindrical piece of steel bored out to receive the piston, which is also the hammer. A small valve controlled by the air pressure admits air on either end of the piston, causing it to reciprocate very rapidly and to strike a blow at every stroke. The chisel is placed on a shank projecting from the cylinder. The tool is then placed against the particle to be removed. A slight pressure of the hand holding the upper end of the tool admits air, which starts the hammer. Externally there is nothing moving, the chisel is kept in contact with the work, as if the operation were a pushing-off process. The amount of work accomplished by this little air tool is surprising, and where much hand chipping is done, opens a way of very materially reducing the cost and labor for such work.

Again, in foundry practice it sometimes happens that large, heavy castings must be broken up to be returned to the cupola, and a small portable drill, with compressed air for the motive power, will allow several holes to be drilled into such a piece, after which a round taper steel wedge with a few well-directed hammer blows will sever the piece; it will then be suitable to be handled for remelting. This little machine has sufficient power to readily drill a ½ in. hole, and weighs about 40 lbs. Its size and weight allows it to be used in almost any place where the air-hose can be attached to it.

In almost all lines of manufacturing there are often disagreeable operations to perform, and probably one of them is the breaking of pig iron. This is not only a hard, laborious task, but one that a man does not care to stick at for any length of time. This can all be changed where air pressure is available. The machine is quite simple in construction, being a cylinder fastened to an upright piece with a weight attached to the piston-rod, with a hollow anvil block at the bottom. The pig bar is then placed on this block. A lever which controls the valve admits air under the piston, raising a 300 or 400-lb. weight; then, by a reverse movement of the lever, the air is quickly exhausted, down comes the weight, breaking the iron in the middle. Each end is again placed under the hammer, and one blow generally has the desired effect, saving much time aside from saving disagreeable labor.

The idea of having portable sand-shifting machines has many advantages over the belt-driven machines, which are located in a fixed position and sand conveyed to and from them. The sand sifter fixed with the necessary mechanism for compressed air can be moved from place to place to perform its work, which results in the saving of time usually re-



KING'S DOUBLE HOPPER-BOTTOM GONDOLA CAR OF 60,000 LBS. CAPACITY, BUILT FOR THE LEHIGH VALLEY RAILROAD.

quired to convey many tons of sand to and fro. The machine is not unlike the ordinary power or belt-driven kind. The change is in having the air do just the service performed by the belt. Wire-wrapped hose is the conducting pipe.

Compressed air certainly has a wide field of usefulness, and can accomplish much in the foundry with a decided saving resulting. The plant is not necessarily expensive to inaugurate or maintain. The average foundry, with a plant costing from $800 to $1,500, can make a good showing. The writer would only suggest that once this labor-saving element is introduced in the foundry and elsewhere, many additional applications will continually suggest themselves to the ingenuity of the progressive operator.

HOPPER GONDOLA CAR, LEHIGH VALLEY RAILROAD.

THE Lehigh Valley Railroad Company placed an order some time ago for a large number of hopper-bottom gondola cars, to be used in their coal service, which embodied in their construction and design the best practice that has resulted from the long experience with coal cars upon this road. The cars are equipped with the Fox trucks, the Westinghouse automatic air brake of the latest design, and the national hollow brake beam. The Gould M. C. B. yoke coupler is used, together with the Schoen draw-bar side lugs.

In the construction of the double hopper, the King arrangement for closing the doors is used. It will be seen from an examination of the side elevation and section of the car published on page 358, that there are two hoppers sloping down toward the centre from a cross-sill just above the inner truck wheel, leaving about 7 ft. of floor to be cleared by shovelling. The doors swing inwardly toward the centre, and are held out in a closed position by a yoke acting as a knee joint that is held down in the closed position by the set of crank arms and levers shown in the side elevation, the shape of the joint being clearly shown in the plan. Thus the two doors brace against each other, and no extra strain is thrown upon the fastenings by the weight of the coal, while the doors are readily dropped by a comparatively light pressure.

The trucks are shown in great detail by the engravings, upon which the dimensions are very fully given, so that an examination of the same will give a better idea of the truck than an extended description.

It will be seen from the plan that the centre sills extend the whole length of the car. The centre and intermediate sills are of yellow pine 5 in. × 8 in., and the outside sills are of the same material, but 10 in. deep. The cross sills at the trucks are 5 in. × 8 in., of oak, and those at the centre, upon which the doors are hung, are 4½ in. × 10 in.

It will be noticed that the high sides of these cars are strengthened by a cross bolt protected by an angle iron, as recommended by the M. C. B. committee on this subject and reported in our last issue.

The body bolster is of the regular type used on the Lehigh Valley rolling stock. The ends are turned down and welded, as described in the AMERICAN ENGINEER for November, 1894. In the construction, white oak is used for end sills, draft timbers, stakes, all blocking for draft timbers, flooring, doors and chute planking.

The body is braced by two 1¼-in. truss rods that are upset to 1⅛ in. at the ends, and which pass over a truss post over the body bolster that is cast solid with the step to which that bolster is bolted.

While it is impossible to say that this or any other car represents a distinct departure from current practice, it may still be regarded as a type of the most approved construction for this class of car at the present time.

The principal dimensions of the car are as follows:

Length over end sills	31 ft.
" inside end planking	28 ft. 6⅛ in.
Width over side sills	8 ft. 11 in.
" inside side planking	8 ft. 5⅛ in.
Height top of sills to top of planking	4 ft. ¾ in.
Distance between centres of car bolsters	20 ft. 6 in.
Size of hopper opening	50 sq. ft.
Truck-wheel base	5 ft 2 in.

TUBULOUS BOILERS IN THE FRENCH NAVY.

ASSISTANT ENGINEER JOHN K. ROBINSON, U.S.N., has contributed an article to the *Journal of the American Society of Naval Engineers*, in which he gives the results of his observations on the working of water-tube boilers on French ships, and in which he says:

"There are only three types which can be said to have any chance of replacing the Scotch boiler: the Belleville, the D'Allest, and the Niclausse. Other types essay to fill the places of these boilers, but, so far as I know, the three named are the only types that are used in vessels larger than gunboats. Others have been tried with a view to applying them in large vessels, but so far they have not been a success.

"Of the boilers mentioned, the Belleville is the oldest type; it is claimed for it that it is also the oldest tubular boiler, and it probably is the oldest French one. It is too well known to require description, but some consideration of its working may not be out of place, when it is considered that the results are those reached where the experience has been greater than ours

"The extremely small quantity of water in the boiler has made the use of an automatic feed-regulator necessary. This regulator works well when it does work, but fails to work at all often enough to destroy all confidence in it. Besides, when the regulator fails to work serious accidents often result. The amount of feed-water is so small that any failure of the regulator to act is liable to cause the water to disappear entirely from the boiler. The small quantity of water in the boiler likewise causes large variations in the steam pressure, and necessitates a larger pressure in the boiler than at the engines—that is to say, there is a reducing-valve between the boilers and the engines.

"The slow circulation of the water causes the tubes to deteriorate very rapidly if the water is not pure. The tubes of the lowest row are made very thick, but they wear out very rapidly nevertheless, being bent after fires are lighted under the boilers two or three times.

"The system of circulation of the water causes a great deal of 'priming,' and this cannot be cured even with the use of a complicated set of baffle plates in the steam drum of the boiler, and with the addition of a separator between the boilers and the reducing-valve. The reducing-valve must also reduce the amount of water in the steam, though, as has been seen, this is not the prime object of its use. It has been estimated by engineers that have worked these boilers for several years, that the amount of water in the steam at the cylinders is never less than 10 per cent.

"The use of the Belleville boilers was said at the outset to be sure to give a great gain in economy of fuel. In fact, many engineers still seem to think that they are not greatly inferior to the Scotch boilers in this respect. The fact is, however, that the arrangement for the combustion of the coal to take place entirely in one place has made the mixing of gases of combustion very poor. To insure proper mixing all the gas from the grate should be brought together at some point before the combustion is supposed to be completed. This would correct the inequalities in the thickness of the fires in different parts of the grate. So very poor is the mixing of gases in the Belleville boiler, that it has been found necessary to have a pump for forcing jets of compressed air in the top of the furnace, forcing the gases of combustion down toward the grate, and so promoting their thorough mixing.

"The absolute necessity of a sure-acting feed-pump has led to the use of a specially designed pump that will always be sure to act. This result is obtained at the cost of a large amount of steam for the pumps, but the result is so necessary that it has been said that the pump is what makes the boilers.

"The accessories to this boiler are so numerous that they make a considerable addition to the machinery of a vessel. The number of separate machines that are required to make this boiler act in at all a safe way leads to an exaggerated amount of repairs, and the care of the steam-producing plant becomes a more difficult matter than that of the engines. The repairs to the boilers are more costly than those for ordinary boilers. Not that any one case of repairs is not cheaper than a similar job would be with Scotch boilers, but the greater number of repairs has led to greater expenses for the government in the repair shops. The repairs can, however, be made in a much shorter time than with the cylindrical boilers, and this must be held to counterbalance in a large degree the greater frequency of break-downs in the boilers. Also the large number of boilers in the steam-producing plant of a powerful ship makes the loss due to the putting out of commission of any one boiler a minimum. It is also to be noted that all ships that are fitted with these boilers have more boilers than are necessary to the running of the engines at full power. Thus it is always possible to run at full power even with one or more boilers disabled.

"The advantages of the Belleville boiler over the Scotch boiler that are the most appreciated in France, are the great gain on the weight of the steam-producing plant, even with a reduction in the forcing of the boilers and the ease of raising steam. The pressure allowed for this boiler is practically unlimited by the boiler, on account of the small diameter of the cylinders that contain the steam. The parts are small and

can easily be removed from the boiler-rooms without cutting any holes in the decks. In fact, the whole boiler may be removed from the boiler-room without troubling the decks at all.

"The manufacturers of this boiler claim that it is possible to use salt water in it without any bad effects. Though it has never been intended that they, more than any other working at a high pressure, should be usually fed with salt water, it has been occasionally necessary to use salt water in them. The results have not been of the best. The tubes were found to be eaten away, and the rods of the feed regulator were soon covered with incrustations that prevented it from acting, and so entirely destroyed the boiler.

"As has been said, these were the first French tubulous boilers. While Mr. Belleville has been constantly at work devising methods of making his boiler run with success, other people have been busy devising some way of getting around the difficulties in the Belleville boilers by a change in the system. . . .

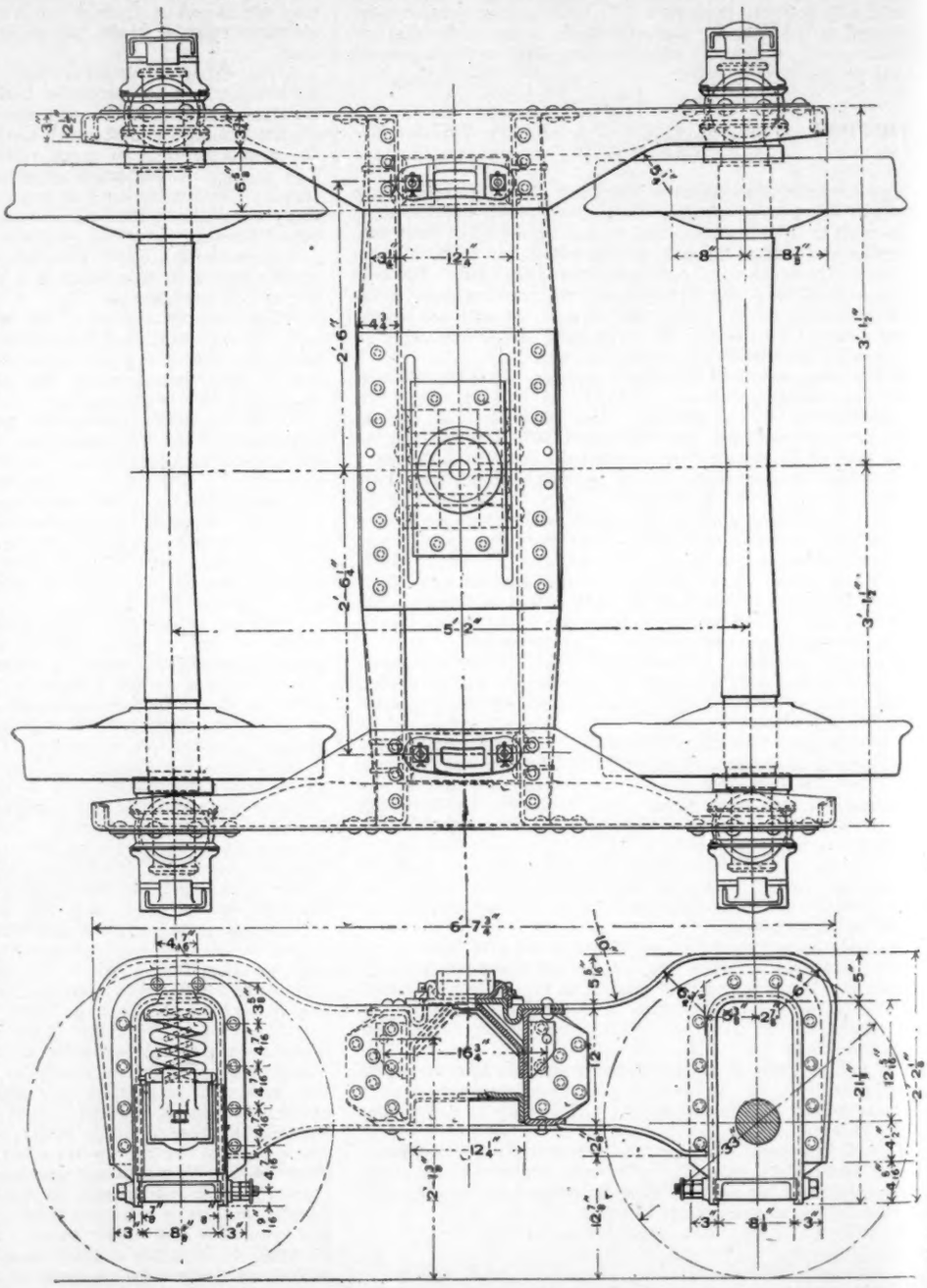
THE BELLEVILLE BOILERS OF THE "AUSTRALIEN."

"The Messageries Maritimes is one of the greatest steamship companies of France, if not the very greatest. This company began the use of Belleville boilers some five or six years ago. The officials of the company seem to be fairly well satisfied with the performance of them, but there is a tendency to obtain something that will give better economical results. Designs were prepared in the last vessel designed (the *Ernest Simon*) for the use of Scotch boilers. There was still a question as to which type of boilers would be adopted when I left France. . . .

"The watch for four hours consists of one engineer, two chief firemen, three first-class firemen, two Arab leading men of the fire-room, eight Arab firemen, six Arab coal-passers, two European oilers, two Arab oilers; total, 26 men. . . .

"There is always danger of tubes giving way with the use of salt water, and the boiler is then of no use until the tube is replaced. This is of little danger in any other way, as the breaking of a tube is dangerous to those in the fire-room only if the furnace-door is opened by the first shock. After that there is no danger of the steam entering the fire-room. The average life of the tubes is from two to three years. The causes of burning are the failing of feed, or the internal corrosion in the tubes, which is the result of use in whatever conditions.

"The feed regulator is liable to fail in use. The wire test placed on each regulator is used as often as possible, say every hour. Nevertheless, the regulators are apt to give trouble by "going to sleep." This may be caused by the formation of deposits on the regulator rods, or on the valve itself. Even dust on the outside of the regulator, on the moving parts, is liable to cause it to fail to act. As one of the engineers on the *Australien* said: 'A regulator may not fail for four hours, but then again three or four of them may fail in that time.' All the water levels are protected, and fully as much attention is paid to them as with the ordinary boilers, but frequently the regulator will fail, and the drop in the water of the boiler will not be noticed till too late. The great trouble with the regulator is that when the water is lowest the effort on the regulator is the greatest, and several times they have opened after the water had entirely disappeared from the boiler, and even when the boiler was red-hot. In that case it is clear something had to break. It was always a tube or tubes. In one case tubes of every element in a boiler burned out at the same time, and due to the above cause. This failure of the feed, due to a failure of the automatic feed, is the cause of most of the accidents to the boiler. The engineers of the Messageries Maritimes have tried to do without the regulators, but have not succeeded in regulating the water well enough in this way to run them without a man on each boiler with that for his duty and nothing else. As soon



PLAN, SIDE ELEVATION, AND SECTION OF THE FOX PRESSED STEEL TRUCK, USED ON THE DOUBLE HOPPER-BOTTOM GONDOLA CARS, LEHIGH VALLEY RAILROAD.

as the regulator is found to have failed, which will generally be discovered when a tube bursts, the fires are drawn from that boiler. It requires about ten minutes to empty a boiler and to burn out a tube after the regulator fails. . . .

"As summed up by one of the ship's engineers :'

"'The great advantage of these boilers is the ease with which they can be repaired. A tube can be replaced in two hours, and this is the most frequent accident to the boilers. The tubes are the weakest part.

"'The Belleville feed-pump is what makes the boiler. It is perfect.

"'The ejector is good for what it is intended. With fresh feed-water, even without a filter (which would be a great improvement), and by adding lime to the feed all the time, there is no danger from any deposits in the tubes. There will always be some deposits in the tubes, but nothing to speak of.

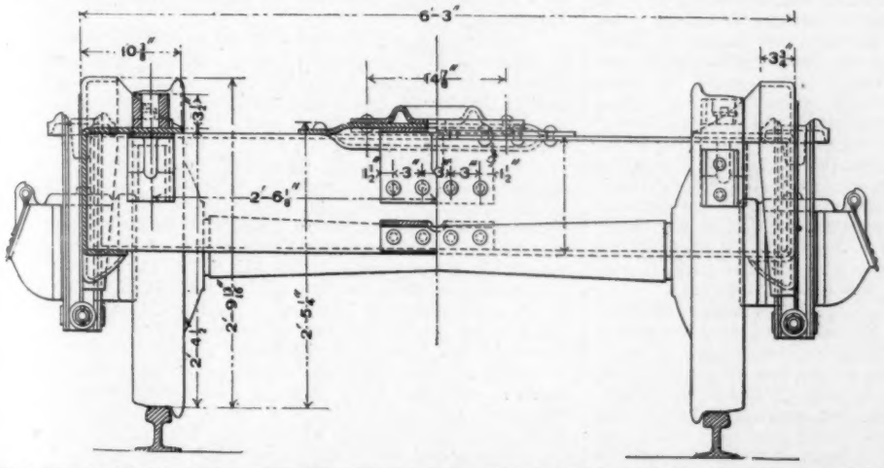
"'The reducing-valve is very good, and always works well.

"'It is rare that there is sufficient priming to interfere with the working of the engines, although it is always considerable.

"'It is not possible to keep up the water level by hand, except by using a man for each boiler for this purpose. The great trouble comes from the use of even a small quantity of salt water in the boilers. The regulator is soon clogged up and does not work, and then firing must be stopped. Yet some feed regulator is indispensable.

"'The firing is difficult. An ordinary fireman can never succeed here.

"'The Belleville boilers are much less economical than the ordinary ones, and the cost of making repairs to them is greater than for Scotch boilers. Besides this their first cost is greater.



END ELEVATION OF FOX PRESSED STEEL TRUCK FOR DOUBLE HOPPER-BOTTOM GONDOLA CARS, LEHIGH VALLEY RAILROAD.

"'Great care has to be exercised with all these delicate machines, and you can never tell what will be the next thing to break down.

"'If you want Belleville boilers, you must have engineers everywhere.

"'It seems to me that there is no doubt that the ordinary (Scotch) boilers are the boilers to have, and that there is no use of bothering one's self with all this machinery.

"'If the regulator sticks, the boiler must be put out of use.

"'The automatic separator trap is not satisfactory, and is always worked by hand.'

"An attachment has been fitted permitting the fires to be drowned with water while on the grates.

"The Belleville boilers show a saving in weight over Scotch boilers about equal to the weight of the water in the latter, and a saving in space of about 7 per cent. This saving in space varies according to the ship from zero to 10 per cent.

"The ratio between the heating and the grate surfaces is about 30.

"The cost of running the engines of the *Australien* during the year 1893 was 2.30 lbs. per I.H.P.

"The estimates for this ship called for a speed of 19 knots on the trials (17.52 realized), and for 17 knots in ordinary running (14.60 realized). The cost of the power was set at 1 54 lbs. per I.H.P. It is evident that these boilers have not been remarkable in their economy.

"On the ships of this line which use Scotch boilers, and those of an old type with pressures of 90 and 100 lbs. with old compound engines, the cost of a H.P. during the year 1893 was 2.02 lbs. per hour. If the use of triple-expansion engines gives an economy of 20 per cent., the cost of the Belleville boilers in coal alone exceeds that of Scotch boilers by 42 per cent.

"If the *Australien* had been fitted with Scotch boilers, she could have made a trip to Australia with a less weight of coal and machinery than with the present boilers. The question of cost, it will be remembered, has not been touched upon.

BELLEVILLE BOILERS IN THE FRENCH NAVY.

"Nearly one half of the vessels now being constructed for the French Navy are to be fitted with Belleville boilers. Those now in use have given fair satisfaction. . . .

"The lack of economy of these boilers has been condemned in the Navy as in the merchant marine. On the trials of the *Brennus*, a battleship fitted with Belleville boilers, and the largest ship, in point of power at least, to be fitted with them, the results of the preliminary trials were most unsatisfactory. The coal per I.H.P. was 3.95 lbs. on one trial ; and later, when the firemen had become more accustomed to the boilers, this figure was reduced to about 2.45 lbs. This is at the most economical rate of speed for the ship. In calculating the consumption of the engines, there is an auxiliary boiler that supplies all the auxiliary machinery except the air and circulating pumps, and the power of the main engines is used for the calculations. The power of the feed-pumps is neglected, and acts as a loss for the boiler furnishers. Neither of these trials was long enough to necessitate the fires being cleaned. . . .

THE D'ALLEST BOILER.

"The D'Allest boilers are not quite so heavy as the Belleville, but the floor space occupied is greater for the same area of grate or heating surface. As, however, the D'Allest boilers are much more capable of being forced than the Belleville (which are uneconomical with over 15 lbs. of coal burned per square foot of grate), it may be said that the space occupied by the D'Allest boilers is not greater for the same power than that required by the Belleville. A great advantage for the D'Allest boilers is, that with them it is unnecessary to have more than the ordinary auxiliaries of the Scotch boilers, and the frequency of repairs with the Belleville boilers is thus avoided. The amount of water in the D'Allest boilers is not, of course, so great as in Scotch boilers, but it is sufficient to make the use of that bugbear of the practical engineer, the automatic feed regulator, unnecessary. The cost of running the D'Allest boiler is far less than that of the Belleville, and, indeed, it may be said that on this point the D'Allest boiler may be compared with the Scotch. It has an independent combustion chamber, and thus the gases are well mixed before entering the uptake. The results of steaming with this boiler are in marked contrast with those from the use of the Belleville. While the D'Allest boilers have not required more coal than Scotch boilers for similar engines, the loss in coal has been with the Belleville boilers as much as 42 per cent., as will be seen later.

"The greatest advantage of the Belleville boilers over the D'Allest lies in the comparative freedom of the tubes of the Belleville boiler to expand when heated, they being fastened at only two points in each element, while those of the D'Allest are fastened, the same as the tubes of Scotch boilers, at both ends of each tube. This reduces the danger of leaky tubes in the Belleville below what it is in the D'Allest boilers. Another advantage of the Belleville over the D'Allest lies in the fact that the parts of the former are smaller than those of the latter, and that, therefore, there is less difficulty in removing them from the fire-rooms in case of injury beyond repair. When one considers the fact that the French Government requires reducing-valves to be placed between the boilers and the engines whenever tubulous boilers of any type whatever are used, some excuse for the use of the Belleville in preference to the D'Allest boiler may be found. Of course, the question of the advisability of using any type of tubulous

boilers is quite apart from the question of the superiority of one tubulous boiler over another.

THE NICLAUSSE BOILER.

"Of the many other types that have been proposed for replacing the Scotch boilers, there is but one—the Niclausse—that has so far been recognized as possessing the points that are requisite for use in men-of-war. These boilers are modifications of the Collet. The differences between the new boiler and the older one lie almost entirely in the details of construction, the main points of the boilers being the same. These boilers are as different from the others as the latter are from each other. They are compared only with the D'Allest, as the latter are so evidently superior to the Belleville that it would be waste of time to include a second comparison.

"The weights of the D'Allest and the Niclausse boilers are practically the same for the same area of heating surface, with the same advantage for the Niclausse in regard to the space occupied as for the Belleville boiler. But while the Niclausse boilers are capable of being forced more nearly to the power of the D'Allest than the Belleville boilers are, they are not the equals of the D'Allest in their capacity for high powers. It may, therefore, again be said that the D'Allest boiler takes up less space for the same power than the Niclausse. Both of these boilers give dry steam at the highest powers at which they are run, and, therefore, have a point of advantage over the Belleville. The amount of water in the Niclausse is less than in the D'Allest, but it is still large enough, so that the water level may be easily maintained without the use of any other than the ordinary check-valves on the boilers. The greater the amount of water in any boiler, however, the better it is for keeping a steady steam pressure; and some difficulty was experienced in maintaining the pressure of steam constant during the forced draft trials of the *Friant* (fitted with Niclausse boilers). The frequency of repairs to one of these boilers is about the same as for the other, and the cost is about the same in each case. The joints in the Niclausse boiler are all metallic and conical, and so require more care in the making, but are less liable to give trouble when once made. The tubes are all free at one end, and therefore the danger of leaky tubes is reduced to a minimum. In fact, during all the trials of the *Friant* there were no leaks in this boiler. It is another point in its favor that the repairs are all made from the front of the boiler. It must also be remarked that it is easier to mount and dismount a tube in the Niclausse than in any other type of tubulous or other boiler. The complete operation of removing a tube and replacing it with another took, in one instance, within my observation, less than two minutes.

"The advantages that the D'Allest boilers have are chiefly in the matter of economy. As has been said, they are about as good as the Scotch boilers, while the Niclausse or the Belleville give much poorer results in actual use than have been found from the use of ordinary boilers. Another advantage of the D'Allest boiler lies in the fact that the tubes in the rows next to the fires are all Servé tubes, and thus much less liable to burn out than ordinary tubes. It would be hard to use this type of tubes in the Niclausse boilers, on account of the inner circulating tube in each element. It would seem that tubes of the type used in the Niclausse boiler are the best, however, on account of their freedom to expand when the boiler is being fired. The one great advantage of the D'Allest boilers seems to lie in their great relative economy over any other tubulous boilers. Mr. D'Allest himself says that this advantage is almost if not entirely due to the use of an independent combustion chamber. There would be little difficulty in adding a combustion chamber to the Niclausse boiler, and then it would seem that this boiler would be inferior to the D'Allest in but the detail of the amount of water in the boiler. This defect could be remedied by a change in the size of the tubes to allow for the increased rate of evaporation rendered possible by the addition of the combustion chamber, and by the use of a larger steam drum at the top of the boiler. Perhaps even now it may be said to be a question whether the Niclausse boilers are not the equals of the D'Allest, but the opinion of the French engineer seems to be that the D'Allest are the boilers of the future, and that, with a few changes, they can be readily supplied in the place of the Scotch boilers. The addition of hydrokineters would reduce the disadvantages of the D'Allest tubes being fixed at both ends. This apparatus has not yet been used in these boilers.

"In the use of these boilers in the French Navy it is to be remarked that even with the number of spare boilers (20 per cent. in many cases), and with the small rate of combustion allowed in all cases (never above 31 lbs. of coal per square foot of grate), and with engines that are considerably heavier than those used for the same power in this country, the total weight of the machinery is not so great as in our latest ships. In no case of a modern French man-of-war fitted with tubulous boilers that I now recollect has the weight been over 200 lbs. per I.H.P. of all the machinery; in most cases the weight is down to about 185 lbs. These figures are, of course, for large vessels of the battleship or fast cruiser type. This seems to be the greatest if not the only advantage for the tubulous boilers. The pseudo advantage of quickness in raising steam is one that is more than counterbalanced by the always attendant greater difficulty in managing the boilers when under pressure.

"The pertinent points that seem to me to need attention in the French boilers are that the tubes are always so arranged as to be easily removed or cleaned. This seems to be an absolute requisite for any boiler that can entirely replace the Scotch boilers.

"Tubulous boilers will always give more trouble to keep in good condition than would Scotch boilers, but they are sure to retain their full efficiency almost indefinitely, as the worn parts are replaced by new ones that are as strong as the old ones were in the first place. There is no shell to deteriorate.

"It is also to be remarked that the tubes used in these boilers are invariably of a larger diameter than is generally used in the boilers made in this country. The gain in the weight of the boilers may be said to be about equal to the weight of the water in Scotch boilers that would have to be substituted for the tubulous boilers."

THE ECONOMY OF STEAM-JACKETS AND SUPERHEATED STEAM.

In a lecture on The Development of the Experimental Study of Heat Engines, delivered in London recently, Professor Unwin said:

"Some time ago I ventured to say that there was no trustworthy engine test which showed that the consumption of steam with a jacket is greater than without the jacket. I believe that is still true, but undoubtedly the economy due to the jacket varies in different cases from 30 per cent. to very nearly zero. Roughly, the jacket is more useful with small engines than with large, with slow engines than with fast engines, but all this amounts to little more than saying that the jacket is most useful in those cases where the initial condensation is largest. Just in proportion as the engine, whatever its type, is of the highest class and most scientific design, the jacket is less useful. No one probably designed better simple engines than Corliss, and Corliss did not use jackets. In an experiment by Delafond on a large Corliss engine at Creusot, the jacket effected an economy of only 2 per cent. The same rule holds with compound engines. Hirn found an economy of 25 per cent. due to the jackets, in a Woolf engine tested in 1855, but since then the compound engine has been improved, and the advantage of the jacket is less. Professor Witz made very accurate experiments with a large compound engine of about 600 I.H.P., provided with jackets both to cylinders and receiver. The trials were strictly comparable, the pressures, temperature ranges, and total power developed being nearly the same. The total condensation in the jackets was 12 per cent. of the steam used, so that the jackets were not inactive. Yet the absolute saving of steam due to the jackets was only 4 per cent., or allowing for heat saved by returning the jacket drainage to the boilers, 6.6 per cent. It is perhaps probable that as the temperature range in the cylinder is diminished by compounding, the temperature gradient from the jacket to the interior of the cylinder is diminished and the rate of transmission of heat decreased. It appears, then, that as engines are better designed, the jacket is of less use, and it is not by means of the jacket that the waste due to cylinder condensation can be got rid of, or the highest economy of which the steam-engine is capable reached. The jacket reduces, but it does not prevent initial condensation.

"Hirn looked for some more powerful way of heating the cylinder wall without causing condensation; he found it in superheating. He constructed in 1855 a superheating apparatus in the flues of the boiler at Logelbach, which still exists. The experiments with superheated steam were carried out between 1855 and 1856, and showed clearly the effectiveness of the method in reducing condensation. Superheating came largely into use in the years 1860–70 in this country in marine engineering practice, having been introduced here by John Penn. In every case in which it was used an economy of coal was realized. Generally, the economy amounted to from 15 per cent. to 20 per cent. It was ascertained that this was due strictly to economy of steam, and not to the utilization in the boiler of heat previously wasted. But the use of superheated steam in this country was gradually abandoned, partly, no

doubt, from some practical difficulties, but chiefly, I believe, because practical engineers had no clear idea why superheating should produce so large an economy, and they were not indisposed to abandon a complication the action of which they could not satisfactorily explain to themselves.

"In Alsace superheating has never been entirely abandoned, and during the last ten years hundreds of boilers have been supplied with superheaters. So far as I can ascertain, no difficulty arises in using steam superheated to 500° F., and in good and large engines the steam consumption is reduced when the superheating amounts to 100° by 15 per cent. on the average. I have no doubt myself that superheating will be largely used again. The practical difficulties exist, but they are not insuperable. No possible improvement of the steam-engine of which we have any knowledge at this moment offers anything like so great a chance of important economy as the re-introduction of superheating, and especially of superheating to at least 100°, or more above the saturation temperature of the steam. I obtained in Alsace, on a very good 500-H.P. compound mill engine, with jackets and every appli ance for economical working, an economy of 15 per cent. Mr. Mair Rumley has fitted a superheater to a Babcock boiler supplying a triple engine, and has obtained an economy of 10 per cent. In both cases the economy is economy of steam, and therefore is not due to any increase of boiler surface, or increase of efficiency in generating the steam. Lately Professor Schroter, of Munich, has been experimenting with a small special compound condensing engine of only 60 I.H.P., running at the moderate piston speed of 380 ft. per minute, and with the not excessive boiler pressure of 165 lbs. per square inch. The high-pressure cylinder is not jacketed. The low-pressure is jacketed with receiver steam. In this case, in a tube superheater of a rather special construction in the uptake of the boiler, the steam is superheated to 670° F., or nearly 300° above the saturation temperature corresponding to the pressure. In two trials of six and eight hours' duration—periods quite long enough for accurate determination of results with so accomplished an observer as Professor Schroter—the consumption of steam was only 10.2 lbs. per I.H.P. hour, and the consumption of German coal of moderate quality only 1¼ lb. per I.H.P. hour. The steam consumption is the lowest on record for any engine of any type or size, and is very remarkable for so small an engine. It is often argued that, as very little heat is required to superheat steam, it cannot produce much effect. The answer is, that a small amount of heat rightly applied in preventing initial condensation produces a disproportionately large effect. That is consistent with the strictest principles of thermodynamics. In the Schmidt engine only 8 per cent. of the heat was used in superheating the steam, and to this 8 per cent. the remarkable economy is due. In a steam-jacket acting well about 12 per cent. of the steam used is condensed, and to this 12 per cent. the advantage of the jacket—which often reduces the amount of steam used in the cylinder by 20 to 30 per cent.—is due. But the heat from a jacket is much less efficiently applied than the heat taken direct to the interior of the cylinder by superheated steam, and used primarily in maintaining the temperature of the admission surface. Further, the quantity of superheat brought into the cylinder in a given time increases with the speed of the engine, while jacket heat diminishes in effect as the speed is greater. The action of the superheated steam is shown clearly enough on the indicator diagrams. In my own trials in Alsace, the wetness of the steam at cut-off in the high-pressure cylinder with jacket—but without superheating—was 35 per cent.; with steam superheated 100° it was only 15 per cent. In the trial with the Schmidt engine there was no moisture at cut off in the high-pressure cylinder, and the steam remained dry till nearly the end of the stroke."

THIRD-CLASS TORPEDO-BOAT FOR THE UNITED STATES CRUISER "MAINE."

In our issue for October, 1894, we illustrated what are undoubtedly the lightest quadruple-expansion engines that have ever been built for the H.P. developed. They were intended for use on the third-class torpedo-boats to be carried on the deck of the cruiser *Maine*, and are now in position. The engraving on page 364 is a reproduction from a photograph of one of these vessels, while the general details of the construction are clearly given on page 365.

Considerable interest cannot fail to be taken in the performance of these boats that will form a portion of the equipment of the *Maine* and the *Texas*, for the latter vessel is also to be provided with them.

The boats are to form a part of the complement of boats for the above-mentioned vessels.

Their function will be to operate from the vessels as a base, hence a small supply of coal. One ton for *Maine's* boats and three-quarters of a ton for *Texas'* boats is allowed, and the boats are made exceedingly light so that they can be readily hoisted on board, the hull and fittings weighing only 13,785 lbs. for the *Maine* and 10,992 lbs. for the *Texas*.

Boats of this class have been furnished to vessels of foreign navies, but up to the present time have never been supplied to vessels of the United States Navy.

The design for hull and fittings was prepared by the Bureau of Construction and Repair of the Navy Department, and the machinery by the Bureau of Steam Engineering.

The two boats for the *Maine* will each be fitted with a bow tube for discharge of an 18-in. Whitehead torpedo, and the two boats for the *Texas*, being smaller, will each be fitted with a deck-training tube for a torpedo of the same type and size.

The frames of the boats vary in size from 1¼ in. × 1¼ in. of 1.5 lbs. per foot to ¾ in. × ¾ in. of 0.7 lbs. per foot, with reverse bars varying from 1⅛ in. × 1⅛ in. of 1.3 lbs. per foot to ⅞ in. × ⅞ in. of 0.7 lbs. per foot.

The outside plating is worked flush, with seam strips on the outside, the sheer strakes being 6¼ lbs. per foot on the boats for the *Maine*, and 5 lbs. per foot for those for the *Texas*. The rest of the plating is 3¾ lbs. per square foot or about three-thirty-seconds of an inch in thickness. The decks are to be of steel, covered with linoleum.

In addition to the torpedo armament, each boat is to carry a 1-pdr. rapid-fire gun, with a suitable supply of ammunition.

Each boat has a single vertical quadruple-expansion engine,* working at a pressure of 250 lbs., the cylinders placed in order of size over the shaft, the high-pressure cylinder being forward.

The following table gives a recapitulation of the principal dimensions of the machinery:

	Maine.	*Texas.*
Diameter of Cylinders. High	6 in.	5.25 in.
1st intermediate	8.37 in.	7.25 "
2d intermediate	11.75 "	10.00 "
Low	15.75 "	14.00 "
Stroke in inches	8	8
Condensing surface, sq. ft.	150	116
Revolutions per minute	675	675
Indicated H. P.	200	155
Type of boilers, Mosher	Tubulous.	Tubulous.
Steam pressure, lbs.	250	250
Grate surface, sq. ft.	12	9.25

The estimated speed for the *Maine's* boats is 18 knots, and for the *Texas'* boats, 17 knots.

The machinery, as well as the hull, is kept as light as possible consistent with the strength required. The weight of the machinery, water, and stores being 11,990 lbs. for the *Maine's* boats and 9,900 lbs. for those of the *Texas*.

The shafting hardly amounts to more than a pipe, its thickness being only three-eighths of an inch. It was necessary to make the external diameter of sufficient size to secure a good bearing surface for the journals. As this would give a strength considerably in excess of the actual requirements if solid, it has been possible to make a relatively large hole. In large shafting the internal diameter rarely exceeds 50 per cent. of the external, while in this case it is more than 75 per cent. A great deal of attention has been given to the question of the stability of these boats, weights being kept as low as possible to give a good metacentric height. The 18-in. Whitehead torpedo, which weighs 875 lbs. with its tube and launching gear, is a little over half a ton. This weight being considerably above the water-line, it was necessary to keep the other weights as low as possible. The engines were located and the framing of the boats so arranged that the cranks would revolve between the floor-plates of the transverse framing, thus lowering the centre of gravity of the engine to the lowest possible point.

The results of calculations for stability are as follows:

At normal condition, ready for service with ammunition, torpedo and crew of five men on board:

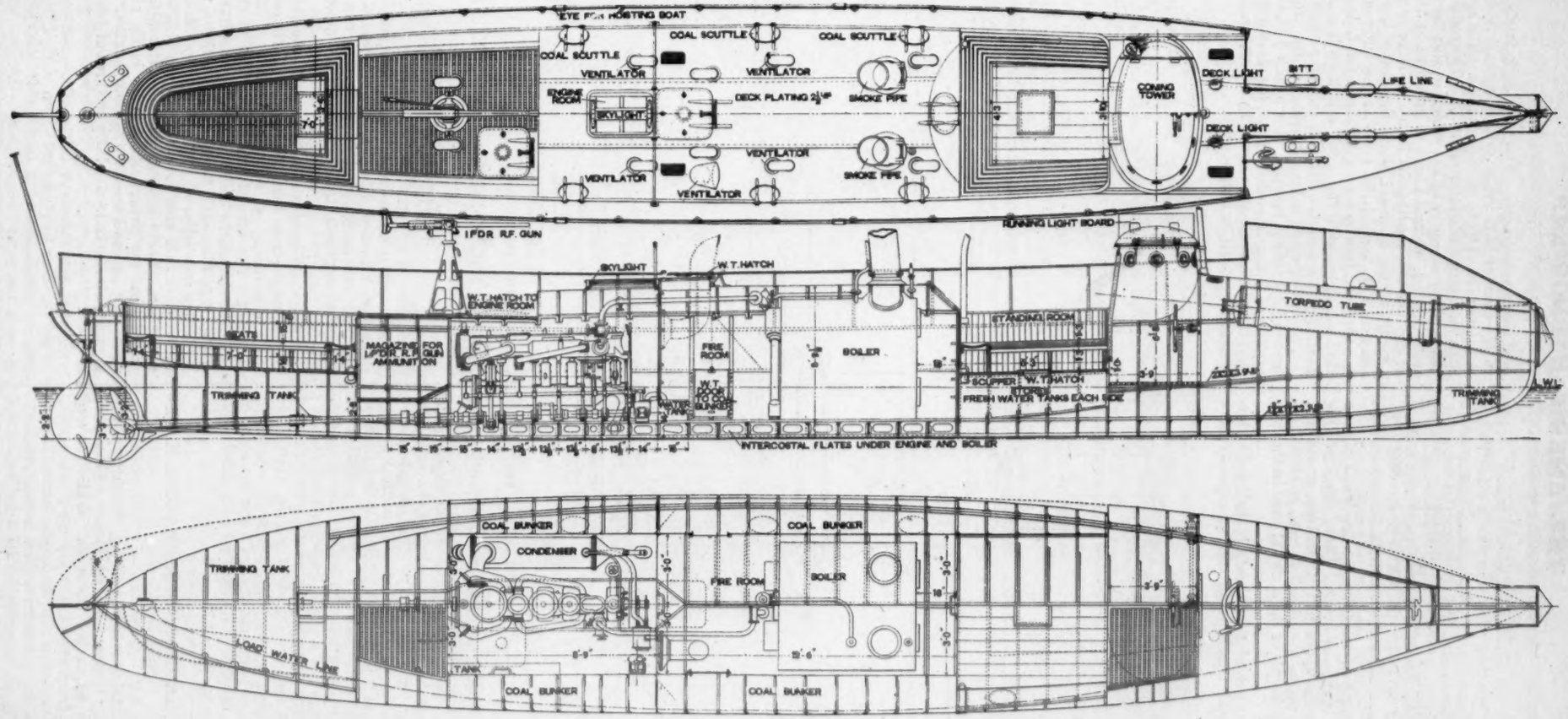
	Maine.	*Texas.*
Metacentric height	1.55 ft.	1.5 ft.
Angle of heel at maximum stability	43°	36°
Righting moment at maximum stability	27,135	16,308
Angle of vanishing stability	89°	73½°

With 30 men on deck in addition to weight at normal condition:

* See AMERICAN ENGINEER for October, 1894.

Photographed by Hart, Brooklyn, N. Y.

THIRD-CLASS TORPEDO-BOAT FOR THE UNITED STATES ARMORED CRUISER "MAINE."



DECK PLANS AND LONGITUDINAL SECTION OF THIRD-CLASS TORPEDO-BOAT FOR THE UNITED STATES ARMORED CRUISER "MAINE."

	Maine.	*Texas.*
Metacentric height	1.00 ft.	.80 ft.
Angle of heel at maximum stability	36°	30°
Righting moment at maximum stability	18,400 ft.-lbs.	7,875 ft.-lbs.
Angle of vanishing stability	67½°	52½°

Calculations for strength of the boats for the *Maine* at their weakest section have been also made. These developed the fact that the strain on the upper part of the boat, or at deck, when on the crest of a wave, would be 0.64 tons, or about one-fortieth of the tensile strength of the material used in the construction of the boats.

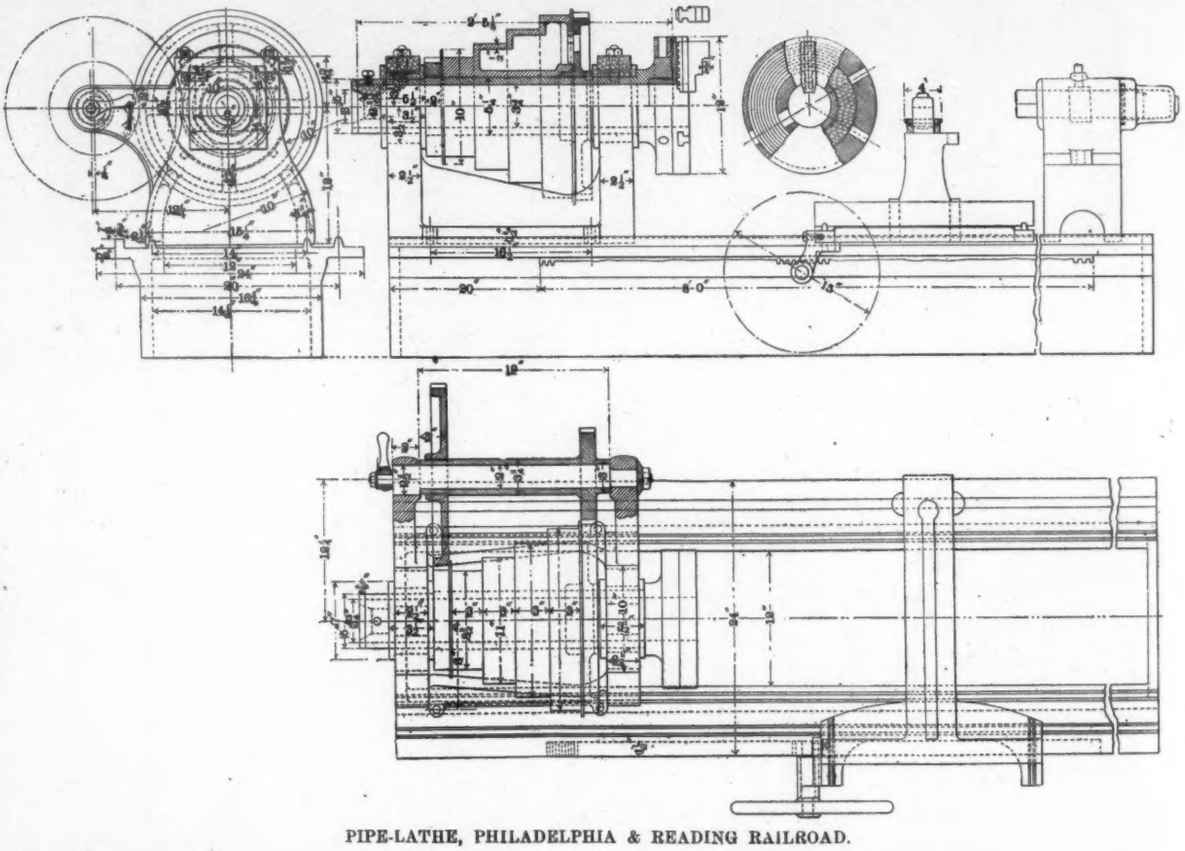
While the primary object of these boats is their use as torpedo-boats, cockpits with considerable seating capacity have been provided so that they can be used as fast dispatch boats, or barges for the admiral of the fleet.

As we noted in our previous description of the engines, the engine and fire-rooms are in separate compartments, and there is no means of passing from one to the other except by way of the deck. This means that the men are confined in very cramped quarters, where it is absolutely essential that the ventilation should be as perfect as possible. Special attention has therefore been paid to the ventilation of the two compartments. The cowls are so arranged as to form downcasts and outlets; the downcasts being arranged well toward the forward end of the compartments that they supply with fresh air. The goose necks are of copper fitted to brass flange rings for connection with the deck plating. The downcast cowls are also made of copper and fitted to revolve, all mouths being fitted with water-tight covers.

PIPE-LATHE, PHILADELPHIA & READING RAILROAD.

Among the tools that have been built at the shops of the Philadelphia & Reading Railroad for home use is a pipe-lathe, of which we give an engraving herewith. While the tool does not vary greatly from others that are upon the market, it is a sample of a good design that does its work well and is giving satisfaction in the place for which it was intended. The bed is of the box type, exceptionally rigid and heavy, the ways of which for the head and tail stocks and carriage extend the whole length. The headstock is also heavy and of such a contour that the requisite strength was obtained with the minimum of work on the patterns. The spindle is hollow, with an internal diameter of 3¼ in. The outside diameter between the bearings is 5½ in., which is also the diameter of the front bearing, while the back is cut down to 5 in. The length of each of the bearings is 3½ in. The brasses are faced and brought metal to metal along the centre line. The spindle projects 2 in. beyond the brass at the outer end, where there is a threaded hole to take a set screw for holding the bushing that is inserted to fit the work and keep it in line. The back gearing has a uniform face of 2 in. and a pitch of ½ in.

The carriage has a long bearing on the front ways, and is moved by a pinion meshing into a rack 8 ft. long and having a pitch of ½ in. By referring to the drawing it will be seen that the dimensions are very fully given, so that a recapitulation of them will be unnecessary.



PIPE-LATHE, PHILADELPHIA & READING RAILROAD.

THE MICRO-METALLOGRAPHY OF IRON.

By Thomas Andrews, F.R.S.

In the course of a research with high microscopical powers (including 300, 500, 800, 1,200, and upward to 2,000, diameters) on the micro-crystalline structure of large masses of wrought iron, the author observed the following novel metallurgical facts:

When large masses, several tons in weight, of practically pure wrought iron were allowed to slowly cool from a white heat, a secondary or subcrystallization of the metallic iron occurred. The normal primary crystals of the iron, or those which have hitherto been regarded as constituting the ultimate structure of the metal, were found to enclose a subcrystalline formation consisting of very minute, and much smaller crystals of pure iron also belonging to the regular order of crystallization. These crystals sometimes manifested the hexagonal form, the predominant angle being about 120°, and often they assumed the form of simple cubes. The secondary crystals were contained within the area of the larger primary crystals.

Typical illustrations of this duplex crystallization found in two large iron forgings are given in figs. 1 and 2, and the relative dimensions of a number of individual crystals are given in the paper.

The results of twenty measurements of the primary crystals

and twenty measurements of the secondary crystals taken on each forging are given on these tables.

The markings of the intercrystalline spaces or junctions of the secondary crystals were very clearly defined, but they were exceedingly minute. The general form, contour, and relative size of the primary and secondary crystals, as seen in section, will be noticed on reference to the accurate tracings, figs. 1 and 2. The linear dimensions of the primary crystals would average about 0 01 in., the linear dimensions of the secondary crystals averaging about 0.001 in.

Judging roughly from the indications of the average micro-measurements, there would appear to be approximately 1,000,000,000 of the secondary crystals in a cubic inch of the metallic iron.

In the case of both the primary and secondary crystals the predominant well-defined angles of the facets of the crystals hovered more or less about the angle of 120°. The majority of the angle readings, made with the goniometre attached to the microscope, indicating generally a hexagonal structure on form of crystallization. There were, however, also perfect cubical crystals observed.

The observations were made with a Ross first-class microscope. The micro-measurements afford an indication of the comparative size of the primary and secondary crystals. These measurements were carefully taken by a Jackson micrometre, and in some cases by a Ramsden screw micrometre, both accurately calibrated with a standard stage micrometre. The wrought-iron forgings on which the observations were made were constituted of practically pure hammered wrought iron, the dimensions of the mass being about 10 ft. long and about 12 in. square. The great length of time required for

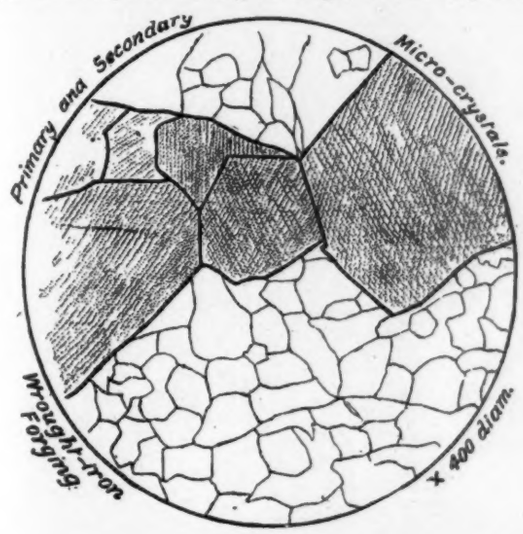


Fig. 1.

such large masses of iron to cool from a white heat appeared to facilitate the production of the crystals of the secondary formation.

The *rationale* of this duplex crystallization has apparently been as follows: The mass of metallic iron on cooling having reached the crystallizing point at about 740° C., the periphery or skeletons of the larger or primary crystals were then formed. As the period of cooling was, however, very slow, the semi-fluid or viscous metal in the interior of these primary crystals was, on finally consolidating, apparently further broken up or subdivided into a considerable number of smaller crystals, enclosed within the boundary or periphery of the primary crystals.

In the course of further experiments on the cooling of large masses of wrought iron, the author has also found, by the use of high power objectives, that the secondary crystals sometimes enclosed a still more minute form of crystals of pure iron, of the cubical form, which may hence be regarded as constituting a tertiary system of crystallization in pure metallic iron. These experiments therefore indicate that large masses of heated wrought iron, on cooling from above the temperature of the crystallization of metallic iron—viz., 740° C.—are capable of crystallizing in three distinct modifications which may tentatively be called the primary, secondary, and tertiary system of crystallization in iron, these various crystalline modifications being all, however, connected with the regular system of crystallization.

The crystals of this secondary formation are not often distinctly discernible in smaller masses of metallic iron, such as rolled rods, plates, or sheets, as these in the course of manufacture rapidly cool, and are frequently manipulated during the finishing processes at temperatures below the crystallizing point of wrought iron (740° C.).

The microscopical examinations were made on carefully prepared and polished samples, etched with nitric acid (1 part HNO_3, specific gravity 1.20, and 49 parts of water), and by the use of high microscopical powers $\frac{1}{8}$ in. to $\frac{1}{15}$ in., and other objectives. The drawings were accurately made with the *camera lucida*. In each observation the etching was prolonged, under constant observation with lenses, a suitable time to develop the accurate structure of the metal.—*Nature.*

WRECKING-CAR—CENTRAL VERMONT RAILROAD.

THE accompanying illustration on page 368 represents a wrecking-car that is in use on the Central Vermont Railroad, and which was built at the St. Albans shops of the Company. It is carried on two four-wheeled diamond trucks, the upper and lower arch-bars of which are formed of 1 in. × 4 in. iron, and the auxiliary and tie-bars of $\frac{1}{4}$ in. × 4 in. iron. The side sills of the car are 8 in. × 15 in. Georgia pine; the intermediate sills are formed of two timbers placed side by side and each 10 in. × 5$\frac{1}{4}$ in., while the centre sill is in one piece as usual, 10 in. × 6$\frac{1}{4}$ in. The brakes are hung outside the wheels, and are attached to the body of the car. The body bolster is formed of a piece of timber 6 in. deep × 16 in.

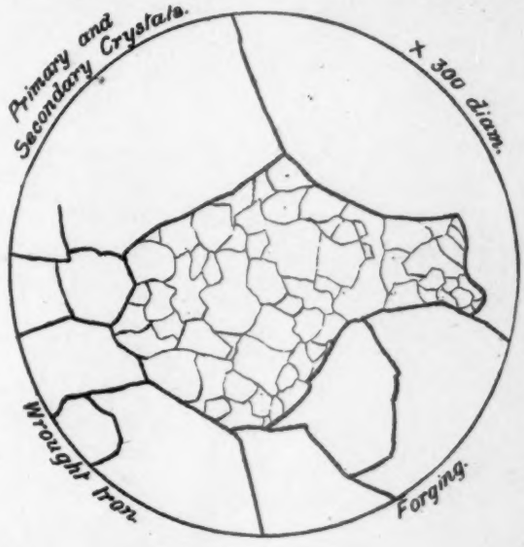
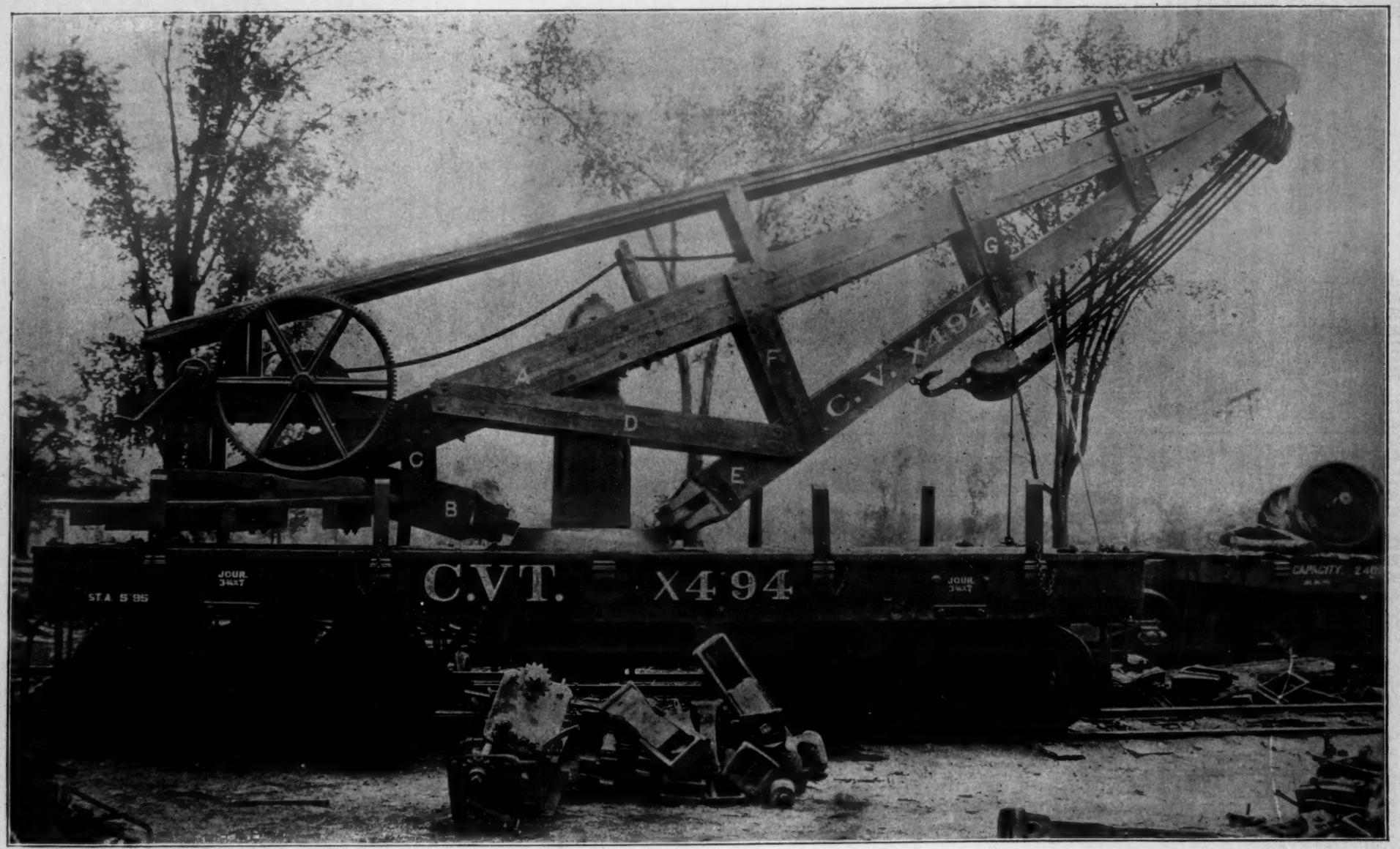


Fig. 2.

wide, and trussed by two $\frac{3}{4}$-in. truss rods. The old type of wooden brake-beams are in use, and the truck, which is of the swing-bolster type, has a transom 9$\frac{1}{2}$ in. deep. The cross-tie timbers are 6 in. × 10 in., dropping down 4$\frac{1}{2}$ in. below the bottom of the side sills and carrying the king posts for four 1$\frac{1}{4}$ in. truss-rods. Filling pieces are placed above the cross-tie timbers, taking up all of the space between them and the bottom of the flooring. There is a longitudinal timber 10 in. × 4$\frac{1}{2}$ in. running from one cross-tie timber to the other, and carried in part by two $\frac{1}{4}$-in. × 3-in. slings that are bolted to the bottom of the side sills. On the top of these timbers, and equally spaced between the cross-tie timbers, are two cross-beams that hold the post of the crane in position. The whole space over the top of the longitudinal beams and between the cross-tie timbers is blocked in, and to it is bolted the bearing casting at the foot of the boom. This casting is 4 ft. 8 in. × 4 ft. 2 in. at the base, with a diameter of 3 ft. 11 in. at the bottom of the inclined bearing and a diameter of 3 ft. 3$\frac{1}{2}$ in. at the top of the same. The post is 20 in. square at the top of the casting, and is capped by a cast bearing piece over which a cast hood is bolted and on which the boom rests. It is also strengthened by a band of 3 in. × $\frac{1}{4}$ in. wrought iron put on just below the cap. The foot of the boom sets in cast-iron pockets that carry the bearing rollers, which are of a conical shape and work against the centre plate, as shown in the engraving.

The sizes of the timbers used in the construction of the crane are indicated by the letters on the engraving, and are given in the following schedule:



WRECKING-CAR, CENTRAL VERMONT RAILROAD, BUILT AT THE ST. ALBANS SHOPS.

A	14 in.	× 5 in.
B	13 in.	× 4⅛ in.
C	9 in.	× 4½ in.
D	9 in.	× 4½ in.
E	13⅛ in.	× 4½ in
G	3⅛ in.	× 4½ in

On the top of the piece *A* extending from the connection of *C* to midway between *F* and *G* a piece of 1¼ in. × 3¼ in. flat iron is bolted. The two pieces of the beam are held apart by six separating pieces.

A 1¼ in. (diameter) manilla rope is used that is given seven supporting parts by means of a three-sheave block and fall. The winding drum has a diameter of 10 in. and a length between flanges of 2 ft. It is upon the same shaft as the large gear-wheel shown in the engraving, and upon which the brake-block is made to bear, just as it does in the wrecking crane of the Philadelphia & Reading Railroad, that was illustrated in our issue for April, 1895. This winding shaft is also provided with two ratchet wheels with pawls fastened to the framing for sustaining the load. The large gear has a pitch diameter of 4 ft. with 120 teeth of 1¼ in. pitch. The pinion on the crank-shaft has a diameter of 8 in. and 20 teeth, the face of both the pinion and the gear being 3¼ in.

The cranks are 19 in. long, so that it will be seen that 1 lb. on the crank-handle will sustain about 80 lbs. at the hook. The cranks are of sufficient length for two men to work side by side upon them.

A box that cannot be seen in the engraving is located at the foot of the boom for the reception of straps, clamps, stays, etc. The brake staffs at each end of the car are square and drop down into a socketed casting out of the way. Hooks are placed on the dead woods at each end of the car for clamping the same down to the rails.

The car is equipped with the Westinghouse air-brake, so that it is in shape for running upon fast trains.

SPECIAL TOOL FOR TURNING BALL-REAMERS.

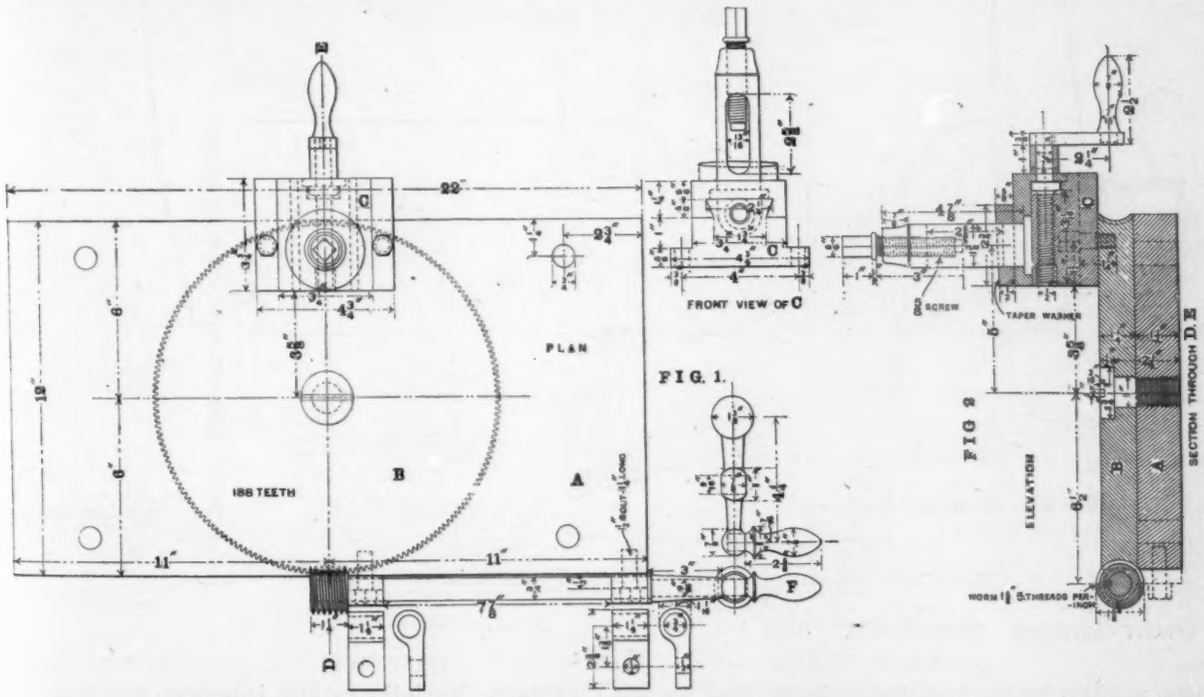
THE attached sketch shows a special tool used by the Baltimore & Ohio Railroad Company for turning ball-reamers—that is, reamers used in balling out steam-pipe joints, etc., and is composed of plate *A*, worm-wheel *B*, slide-rest *C*, and is operated by handle *F*. This tool was designed some years ago by Mr. John Litzinger, who has charge of the tool room for this Company. The mode of operation is as follows:

1. Remove the slide-rest from the carriage of the lathe you intend to turn the ball-reamer in and fasten the special tool to the lathe-carriage with four bolts, passing through bolt-holes shown in plate *A*, and level it properly.

2. Put the ball-reamer to be turned, between the lathe centres with a carrier attached to the shank, the same as you would a straight piece of work.

3. Put a lathe tool in the tool post attached to slide-rest *C*, and by setting the point of the lathe tool any distance from the centre of worm-wheel *B*, and by operating handle *F* it can readily be seen that the point of the lathe tool will describe any radius required within the capacity of the machine.

This tool is used mostly for the purpose of truing off the cutting edges of ball-reamers when they are much worn; it is possible with this tool to take off a very light cut from the cutting edges of the reamers, after which they can be filed to a cutting edge without much delay, and always insure as perfect a ball as it is practicable to get; where with the old templet it is almost impossible to get a satisfactory ball, especially in the case of truing off old ball-reamers.



SPECIAL TOOL FOR TURNING BALL-REAMERS, BALTIMORE & OHIO RAILROAD.

THE DOWN-DRAFT FURNACE FOR STEAM BOILERS.*

By William H. Bryan.

PROBABLY no mechanical device has done as much toward the practical solution of the smoke problem in St. Louis as the down-draft furnace. Until this apparatus was developed there was a certain character of steam plants—or, rather, of steam service—to which it seemed that none of the existing forms of smoke-abating furnaces could be satisfactorily applied. In these plants—fortunately few in number—the demand for steam was such as to make it necessary at times to crowd the boilers far beyond their rated capacity. Or else the work was subject to frequent and extreme fluctuations, often greatly exceeding the rated capacity of the boilers. It may be said, of course, that this is abuse, rather than proper use, of a boiler plant, but, nevertheless, these conditions exist, and it is sometimes impossible either to modify the conditions or increase the boiler capacity.

The fact that there seemed no practicable or reasonable remedy for these cases retarded the growth of the smoke-abatement movement in St. Louis for many years. It was thought unwise to pass and attempt to enforce smoke-abatement ordinances when it seemed impossible for some of the plants to stop the smoke, under reasonable conditions. The demonstration of the fact that the down-draft furnace made a good smoke record possible, even with overworked boilers doing variable work, and with a marked economy in fuel,

* Presented at the Detroit meeting (June, 1895) of the American Society of Mechanical Engineers.

may be said to have marked an epoch in smoke abatement. Our experience in St. Louis leads us to believe that smoke from boiler furnaces can now be abated by practical means, without hardship, no matter what the type of boiler, the character of the work required of the plant, or the kind of fuel used.

I speak thus highly of the down-draft form of furnace with no intention of denying the merits—for they are many—of other smoke-abating devices. Many of these do excellent work under most of the conditions occurring in practice. In my opinion, however, no single furnace now on the market can be adapted to all the conditions met with in every-day boiler service. Each type has a place, a field of usefulness, within which limits its success is sure. Unfortunately, however, the average furnace man seems unable to realize this truth, but offers his device as a remedy for all sorts of cases and conditions. It is not surprising, therefore, that he sometimes meets with failure.

Where the work required of a boiler plant does not greatly exceed its rated capacity, and is reasonably uniform, there are many good smoke-abating furnaces which may be used, some of which will make an appreciable saving in fuel. If our boiler plants were properly designed and managed, and if we did not have sometimes to overwork them, and to subject them to widely varying loads, the smoke-abatement problem would be greatly simplified. The fact, however, that even such discouraging conditions as these can now be intelligently remedied, has led to the preparation of this paper.

Fortunately for the steam-using public, several different forms of down-draft furnaces are offered for sale, by various builders, and under different patents. I have had no opportunity of looking up the number and value of these patents, but it would seem that they refer to important details of construction and arrangement, rather than to general or essential principles. It is not necessary to consider here whether or not the manufacturers are justified in charging royalties. Their experience in the design and adaptation of the furnace to varying conditions—and the further fact that, as a rule, they will guarantee results—would certainly appear to entitle them to a fair margin of profit, at least.

Although the principles are old, I have been unable to find any record of this type of furnace coming into regular use previous to 1888. It seems that the cost of the apparatus, the necessity for water grates, and their frequent burning out, due to defective construction and bad feed-water, prevented its general adoption.

The form of down-draft furnace which has come into most general use, and which may justly be said to have contributed more than any other to the present state of the art, is that invented by Mr. M. O. Hawley, of St. Louis, and which bears his name. Mr. Hawley's experiments began as far back as 1873, and met with varying degrees of success. He was able to show an economy of fuel, and, with proper handling, an almost total abatement of the smoke, even with the low-grade soft coals common in the Mississippi Valley. In 1882 Mr. Hawley interested Captain C. W. Rogers, then General Manager of the St. Louis & San Francisco Railway, who, after consultation with his Master Mechanic, decided to build an experimental furnace in the fire-box of a switch engine. The result was so satisfactory that the furnace was soon applied to another locomotive boiler in stationary service. It was then applied to a locomotive in regular service. It was necessary to greatly cut down the grate area, but in spite of this the engine did good service, being practically smokeless and throwing no sparks, even with a straight stack and no netting, until destroyed by a roundhouse fire. The furnace was also applied to a number of the boilers of the St. Louis & San Francisco Railway Company, in stationary practice, in their shops and other buildings, where they are still running satisfactorily. In 1888 a contract was made to place the Hawley furnace under an ordinary stationary boiler in the new factory of the Hamilton & Brown Shoe Company, St. Louis, under a very stringent guarantee. The boiler was 60 in. in diameter, 20 ft. long, with 18 6-in. flues. A similar boiler was set with the ordinary furnace, in the same room. The results in smoke abatement, fuel economy, and capacity were so satisfactory as to lead to the application of the Hawley furnace to the other boiler very shortly afterward. This case marked the beginning of the introduction of this type of furnace into general stationary practice.

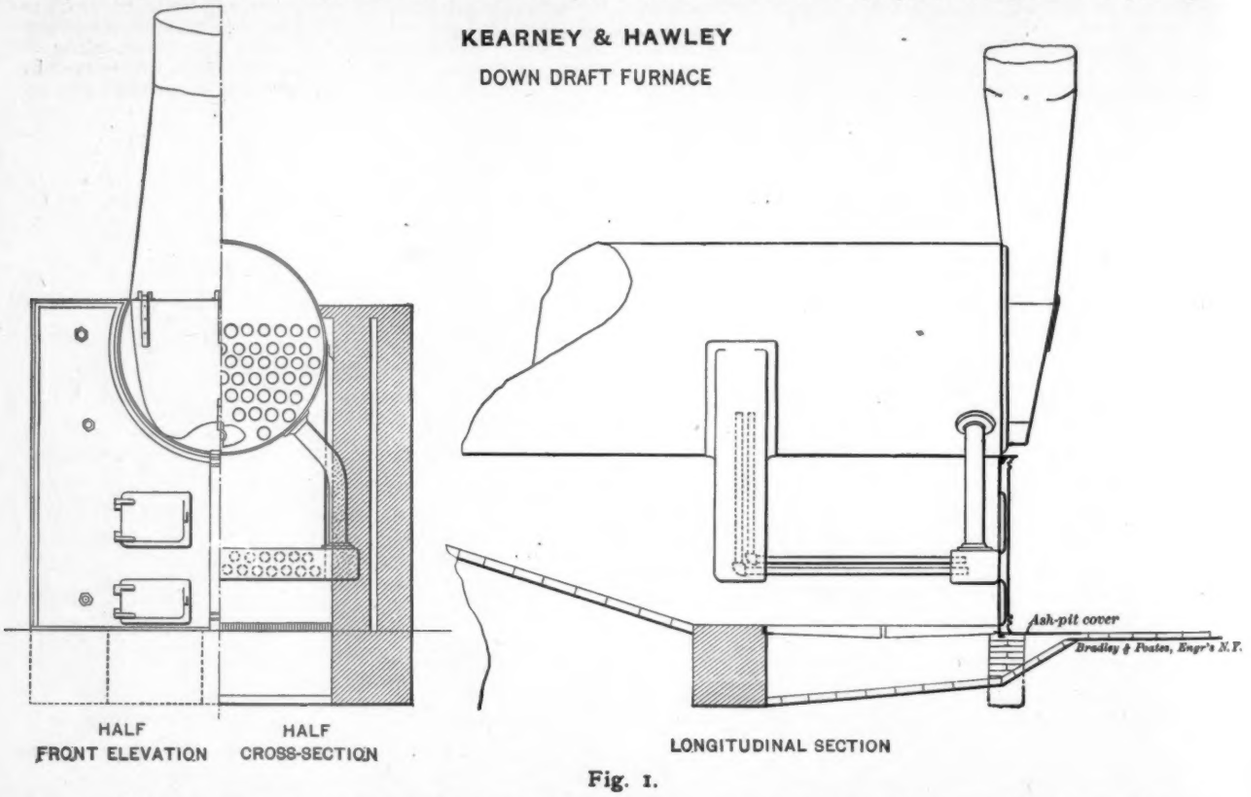


Fig. 1.

A brief description of the characteristic features of the Hawley setting will be of interest. In the earliest forms it consisted of a single row of water grates, these being necessary on account of the high temperatures developed. These water grates were made of 2-in. pipe, placed level, and connected with the circulation system of the boiler by water boxes, or headers, and connecting pipes. The supply pipe leading to the front headers was usually taken from near the bottom of the front end of the shell, and the discharge was delivered near the water-line. The rear end of the fireplace above the grates was closed off tightly, by means of a hanging water leg riveted to the shell of the boiler, in which suitable openings had been cut. In order to insure circulation in the tubes and prevent their burning off, it was found necessary to have the rear end of each tube project far enough into the water leg to permit attaching an elbow, into which was screwed a riser,

reaching up into the main body of the water in the boiler. Further experiments showed that it was usually desirable to put in two rows of water grates, and to stagger them. Even then, however, a considerable amount of unburned fuel fell through the grates, and was hauled out with the ashes, unconsumed. This caused a loss of efficiency when the boilers were crowded, and led to the adoption of the lower grate, which is of the ordinary pattern. This form of the furnace is shown in fig. 1.

It was at the Hamilton & Brown Shoe Works, above referred to, that the necessity for the lower grate became evident, and where it was first applied by Mr. Hawley. It is now an accepted feature of all forms of the Hawley furnace, and to it, in my opinion, are largely due the excellent results secured in capacity, efficiency, and smokelessness.

In the earlier forms of the furnace the water grates were level. It was soon found that, by placing them on an incline rising to the rear, the circulation was much improved, and the probability of burning off tubes greatly reduced. This plan was then regularly adopted, and the pitch gradually increased until the standard is now 2½ to 3 in. per foot of grate length.

It was soon found, also, that the riser pipes in the rear water-box were a source of trouble. Sometimes they became disconnected from the elbows, and when new grates were put in it was difficult to attach the elbows and risers, on account of interference with the other risers and with stay-bolts. When the risers were not connected, the grates burned off in a short time. This proved a serious difficulty, requiring in a number of plants the almost constant presence of boiler

LATEST FORM OF HAWLEY FURNACE

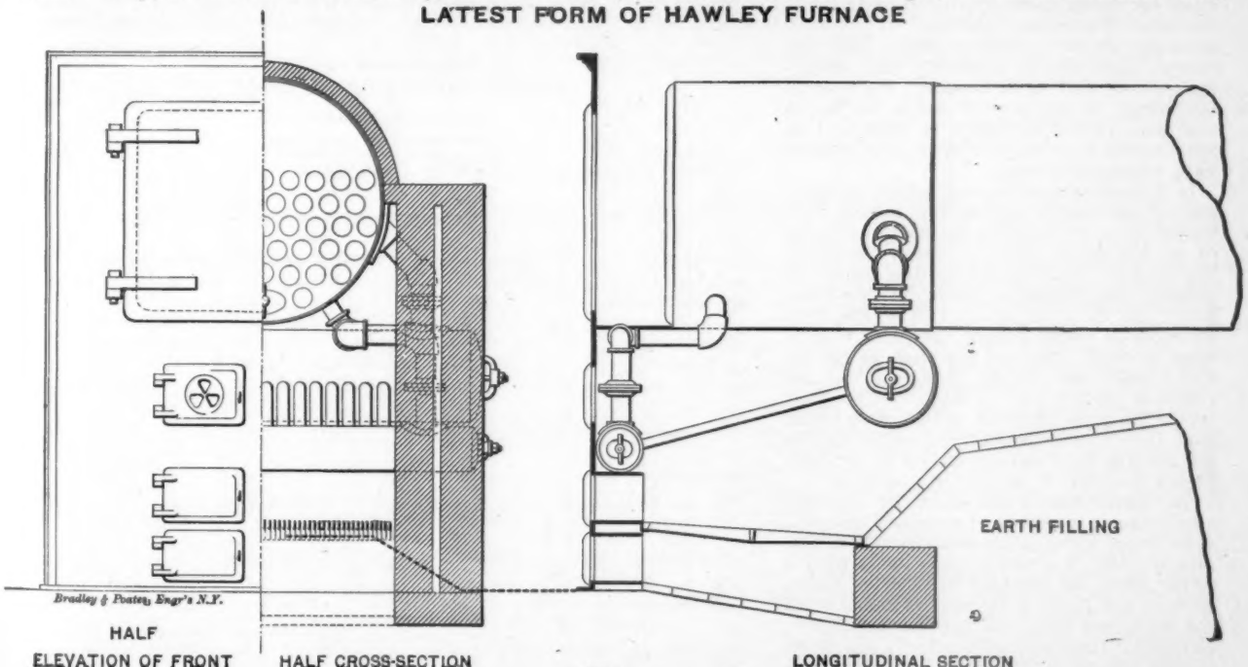


Fig. 2.

makers. Part of the boiler plant was therefore out of service a large portion of the time, and repair bills were large. Experiments were then made with other forms of construction, and a water-box, or header, was finally adopted for the rear end, similar to that used for the front end of the grates, the space intervening between it and the shell of the boiler being built up solidly by a 9-in. fire-brick wall. Connections were made from each end of the rear water-box to the boiler shell, some distance back from the front of the boiler, and just below the water-line. This expedient proved satisfactory, greatly reducing the number of tubes burning off.

This rear drum is now made in two forms. That adopted by the St. Louis manufacturers is simply a riveted drum 20 in. in diameter. This large radius permits the water grates to be screwed in, without the necessity of flattening the sides of the tube, as is customary with the form adopted by the Chicago manufacturers, whose rear drums are 10 in. in diameter. In the St. Louis form the drum is large enough to permit a man to enter it. By placing a light through a hand-hole into the front drum—which is usually 8 or 10 in. in diameter—it is possible to look through every tube, and thus ascertain its exact condition. The large drum, however, offers a favorable place for the accumulation of sediment, which may cause it to burn, on account of the high temperatures to which it is exposed. No such accident, however, has occurred, so far as I can learn. Fig. 2 shows the St. Louis form of construction. It shows but a single row of water grates, this form still being frequently used, as being easier handled.

This figure also shows the present method of building the boiler fronts. In the early form, shown in fig. 1, the ashpit was wholly below the floor-line, and was extended out in front of the boiler front, that portion of it being covered with sheet-iron plates, which were removed when cleaning the ashpit. This arrangement proving unsatisfactory, it was replaced by the three-door front shown in fig. 2. This plan raised the average level of the upper grates to a point some 18 in. above that of the ordinary furnace, making it necessary for the fireman to lift the coal that much higher, and making the firing considerably more laborious. It has now become customary to raise the floor a little at a point some three feet away from the front (see heavy dotted line in fig. 2), thus permitting the fireman to stand at the usual level with reference to height of grate. It is desirable also to have the ashpit slope to the rear, to facilitate cleaning.

As will be clearly seen from the drawings, the operation of the down-draft furnace is directly opposite to that of the ordinary setting. Very little air is admitted below the water grates; the entire supply of coal, and practically all the air, entering above. The fire burns downward instead of upward, there being "no thoroughfare" except downward through the grates. The gaseous products of combustion, together with the finely divided carbon particles which form the visible smoke, are forced through the incandescent mass of coal, and are highly heated, after which they meet the equally hot flame from the lower grates, on which there is burning what is practically a coke fire. The combined water of the volatile matter in the coal, as well as its moisture, are decomposed into hydrogen and carbonic oxide gases. These combine with air supplied below the grate, or drawn downward through it, and burn, thus adding to the efficiency of the furnace instead of impeding it. The separated carbon meanwhile is transformed into carbonic acid gas, which is invisible. The result is almost complete combustion. Such little additional air as is needed is furnished through the registers of the doors between the two grates, or through those of the ashpit, the doors of which are sometimes left partly open also.

In practice it is found that, as an average, the upper grates do probably 90 per cent. of the work. When the boilers are not crowded little or no fuel is burned on the lower grates. When there is a demand for an increased amount of steam the fireman runs his slice-bar along or between the upper grates, causing a considerable amount of half-burned coal to drop through to the lower grates, where its combustion is completed.

It will be seen that the water grates and headers add somewhat to the heating surface, and thus increase the capacity of

the boiler. It has been found, however, that this reversing of the path of the gases, and requiring them to traverse the tortuous passages, makes necessary a somewhat increased chimney capacity, if it is desired that the boilers be capable of doing as much work as with the ordinary setting. If the demand for steam never greatly exceeds the rated capacity of the boiler the ordinary chimney will answer, it simply being necessary to carry thinner fires. The best results, however, in efficiency and smokelessness, as well as in capacity, are secured by having a chimney of ample height; a statement, however, which is equally true with regard to ordinary settings, which rarely have enough chimney.

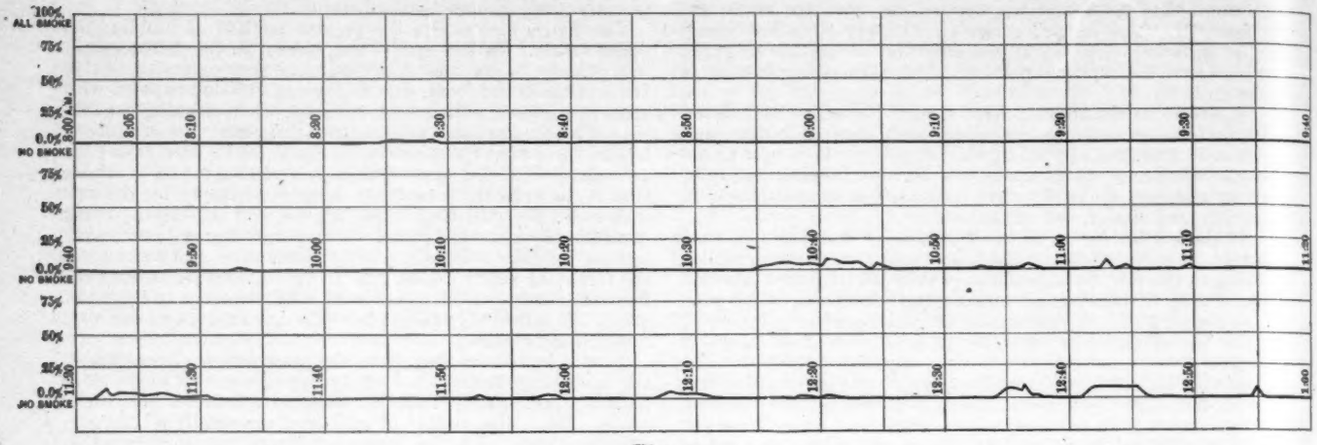


Fig. 3.

In order to make a fair and definite comparison of the Hawley down-draft setting with the ordinary furnace, the Smoke Commission of the city of St. Louis, of which the writer is a member, made a competitive test at the plant of the William J. Lemp Brewing Company, on July 11, 1893. The boilers were identical in every respect except as regards their furnaces, and that the chimney for the down-drafts was 143 ft. high, and for the common battery 100 ft. high, above grate level. In both cases the boilers were run at more than double their normal rating, and the efficiency of the Hawley was over 21 per cent. higher than that of the common furnace.

The smoke record (see chart, fig. 3) shows a reduction in the smoke of nearly 96 per cent., even under these extraordinarily severe conditions. Fig. 4 shows a chart made by the writer from the chimney of a Heine boiler, set with the Hawley furnace, at a time when the boiler was being run at 25 per cent. above its rating. It shows the remarkably low figure of only two-thirds of 1 per cent. of smoke—in fact, there was absolutely no smoke except while the fires were being cleaned.

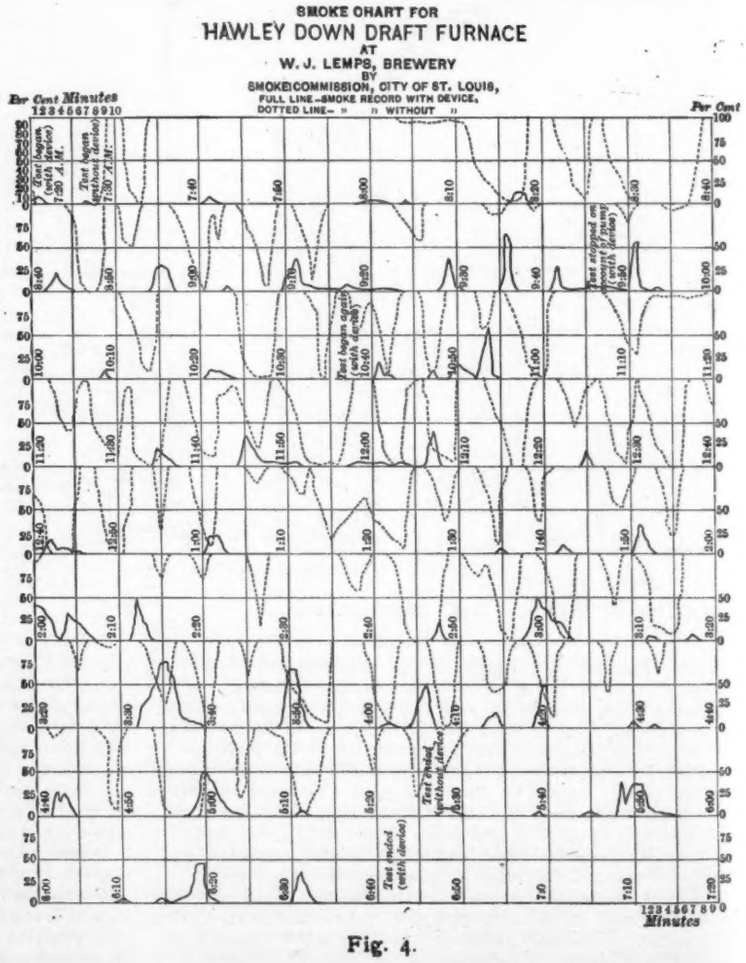


Fig. 4.

It will be seen in figs. 1 and 2 that in the standard form of construction the fireplace is immediately under the front end of the boiler. This usually cuts off from 50 to 60 sq. ft. of valuable shell-heating surface, and, furthermore, must interfere largely with the circulation of the water in the boiler. In a few instances external fireplaces have been built, but their somewhat greater cost, the increased space occupied, the necessity for a special form of front, and the difficulty found in supporting the fire-brick arches over the water grates, have prevented the general adoption of this plan. In my opinion, however, it possesses important advantages in capacity and efficiency, and should be followed wherever sufficient space is available.

With the present form of water-drums and tubes there is but little danger of the tubes burning out unless the feed-water is bad. This is a point that must be carefully looked into when it is proposed to use the down-draft furnace. It is a matter, however, that should always have attention, whatever the type of boiler or setting; and as there are now so many good systems of water purification, there is little excuse for permitting heating surfaces to become foul with scale. When the tubes burn out they do so without causing damage to the surroundings. Sometimes only the threads are stripped, and at other times the tube splits, resulting in a large, but not serious, leak of water. In such cases the boilers are generally run in their regular service until the usual time of shutting down, and cases are on record where the boilers have been run until Saturday night—almost a full week. It is desirable, however, that at least one side of the boiler be accessible, in order to afford access to both drums, particularly with bad feed-water. This necessitates a passage-way between each pair of boilers.

A few cases of grate renewals have been due to careless or ignorant handling of the slice-bar by the fireman, bringing a severe cross-bending strain on the tubes. This, of course, must be carefully guarded against.

There being considerable special ironwork connected with the Hawley setting, this type of furnace is necessarily more expensive in first cost than some others. Measured in results, however, the advantages would, in most cases, appear to warrant a considerably greater investment than is ever required.

The conditions under which it would appear unwise to use the Hawley down-draft furnace for smoke abatement would seem to be:

1. Where the feed-water is quite impure, and cannot be readily improved.
2. Where the feed-water is bad, and the boiler is not accessible from the side.

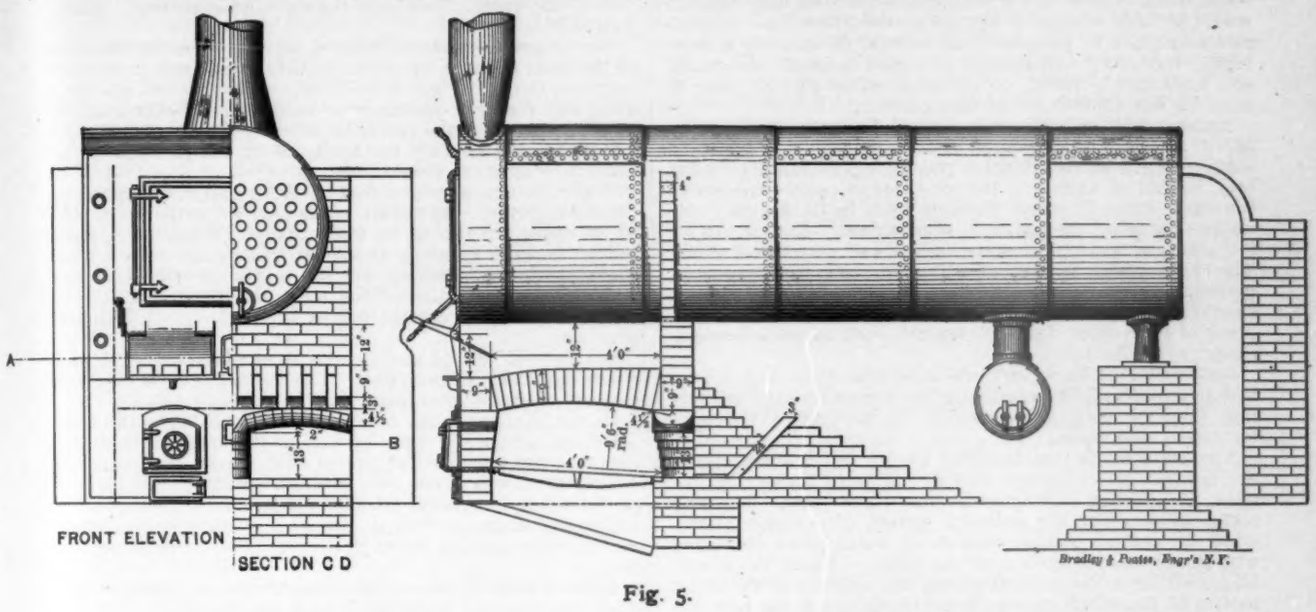


Fig. 5.

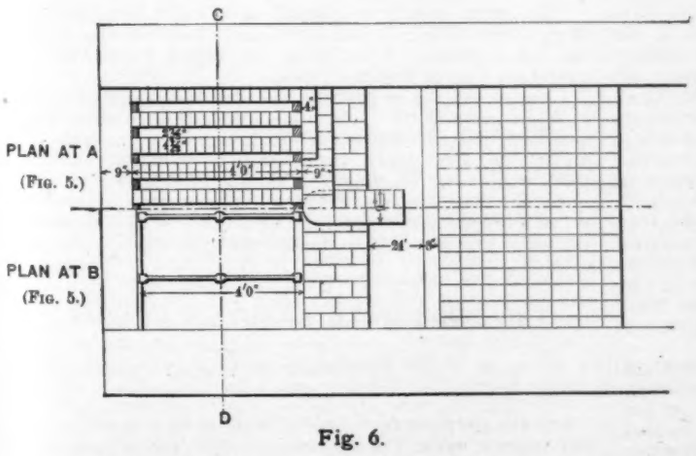


Fig. 6.

3. Where the draft is poor, and the boilers are hard worked. Usually, however, the height of chimney can be increased.
4. Where there is but a single boiler. The possibility of an occasional tube renewal might cause the interruption of the service for several days. This danger would be very remote with reasonably pure feed-water.
5. Where the plant is of such a size or character as not to warrant the investment.

Evaporative tests made by myself and others indicate that the Hawley furnace adds to the efficiency of improved water-tube forms of boilers, although the percentage of increase is not so great as with the ordinary boilers. The design of the furnace is such as to make it readily applicable to any form of boiler.

I recently prepared a series of instructions to firemen for a large plant operating the down-draft furnaces. These are appended hereto. It will be seen that the requirements are not at all difficult of comprehension and execution.

In some cases the use of this furnace has been found to add to the labor cost. This was due in a few cases to the increased height to which the coal had to be lifted, and sometimes to the debilitating effect of the radiant heat pouring out through the open fire-doors into the face of the fireman. Raising the floor level has remedied the former trouble, and the latter has been largely reduced by an improved form of door, which can be so placed as to keep the heat off the fireman, while still admitting an ample air supply. In other cases the draft was insufficient, and large demands for steam have necessitated increased labor. In still other cases the firemen have not thoroughly understood the best method of handling the fires, and have not directed their efforts to the best advantage.

With the latest form of construction, proper draft, intelligent and careful handling of the fires, there would appear to be no reason why the amount of labor should be increased. On the contrary, it ought to be decreased, as there is less coal to be handled.

Not the least of the many advantages afforded by the down-draft type of boiler furnace is the fact that the heating surfaces are exposed to practically constant temperatures. There is no alternate heating and cooling, as is the case with the common setting, when the doors are opened to admit fresh charges of fuel. That this type of boiler setting is destined to widespread use is demonstrated by the fact that three companies alone have within the last five years applied it to 1,600 boilers, aggregating 240,000 H.P.

While the Hawley type of down-draft furnace is perhaps the best known, others are coming into use, which promise well, although none have, as yet, met with very wide adoption. One of these, invented by Mr. Joseph M. Thomas, of St. Louis, is shown in figs. 5 and 6. In essential characteristics it resembles the Hawley, the principal point of difference being the substitution of a series of fire-brick arches in place of the water grates.

It possesses two important advantages: First, the absence of any connection with the pressure system of the boiler, thus avoiding trouble from that source; and, second, the brick arches act as reservoirs of heat, and do not cool the fires as the water grates do. It would be reasonable, therefore, to expect higher temperatures, and increased efficiency and smokelessness. In two tests made by the writer on boilers set with and without the Thomas furnace, my expectations as to smokelessness and efficiency were fully realized. I had expected some loss in capacity, due to the necessarily limited percentage of air-space through the fire-brick grates, but in this I was agreeably disappointed.

The difficulty with this setting thus far has been the short life of the grates, varying from thirty days to six months, depending entirely upon the character of the service, and the care with which the firing is done. Where the boilers are crowded, or where the firemen are careless, the arches last but a short time. If their durability could be increased to an average of, say, four months—which ought to be possible with careful handling, if the boilers are not unduly crowded—the small expense and trouble connected with their renewal would be fully warranted by the improved results. Experiments are now in progress with a view of securing a more highly refractory material out of which to make the grates, and until this is found, no extended effort will be made to push the introduction of the furnace.

Another form of down-draft furnace has been developed by Mr. J. A. Baldwin, of Benton Harbor, Mich. It is similar in many respects to the Hawley, the principal difference being that, instead of admitting the air through open doors above the water tubes, it enters through ducts in the masonry side walls, thus being preheated to some extent. Part of this air is discharged above the water grates, and part below them. The lower grates, instead of being ordinary bars, consist of perforated wrought-iron plates. The preheating of the air should be an advantage, if it is not accomplished at the expense of some other desirable feature, such as smokelessness, capacity, or efficiency.

Only a few of these furnaces have been built, and I have had no opportunity of examining them myself, but I am told that they are doing good work. No accurate evaporative tests have been made.

Another form is that invented by Mr. W. S. Plummer, of St. Louis. Mr. Plummer has all his grate surface on one level, and divides it lengthwise into three parts. The two outer parts are of the ordinary pattern of up-draft grates, while the central portion consists of water tubes connected with the circulation system of the boiler. A solid brick wall blocks off the rear of the fireplace, and extends down to the bottom of the ashpit, except immediately under the rear end of the water tubes. There are two partition walls in the ashpit, running lengthwise, which separate the up-draft from the down-draft portion of the furnace. The firing is done just as in the ordinary furnace, but the only escape for the gases is downward through the central water grates. The plan is working satisfactorily on a small scale in St. Louis, and is now being applied to a large boiler plant, where its operation will be watched with interest. The difficulty would seem to be the necessity for great width of grate surface, it being necessary to get the entire amount of surface in one level, while, in the Hawley furnace, it is divided over two different parallel planes. An increase can, of course, be had by lengthening the grates, but this is not always desirable.

A somewhat similar form is that invented by Mr. E. M. Bosley, of St. Louis, and applied in several cases in connection with his "incandescent" internally fired boilers. He divides his fire-box into two parts, with the dividing line at right angles to the centre of the boiler. The front half consists of an ordinary up-draft grate. In the rear of this is a 10-in. front water drum or header, extending clear across the furnace, and connected by means of 2-in. water grates to a similar drum in the rear. An ashpit of the usual form is built under the front grate, and a closing-off wall above the rear drum. The fire is burned on the front grate in the usual manner, a bed of fire being also carried on the water grates. The path of the gases is up through the front grate in the usual manner, and down through the water grates in the rear. A lower ashpit permits access from the front to the space underneath the water grates.

Both the Plummer and Bosley forms of down draft furnaces appear to utilize the heating surface of the shell immediately overhead to better advantage than the Hawley, but, on the other hand, neither of them have the second grate located where it will catch and consume the droppings from the water grates. So far as I know, no exhaustive investigations or tests of either of these types of setting have been made.

There are other types of down-draft furnace, notably that of Post & Sawyer, of Boston, which I believe has been applied only in connection with their internally fired "complete combustion" boiler, and which does not use a lower grate. The other forms are, in general, modifications of those described here, being few in number and relatively unimportant.

The system in its best shape is not perfect. Much has been done during the last few years in improving details so as to increase the efficiency, durability and reliability of the apparatus, but there is room for further improvements Even in its present condition, however, it is well worthy of the careful study of progressive engineers everywhere.

Instructions for the Operation and Care of the Hawley Down-Draft Furnace, to Secure Efficiency and Prevent Smoke with Illinois Coals.

PREPARED BY WILLIAM H. BRYAN, CONSULTING ENGINEER, ST. LOUIS.

Fire frequently and in small quantities. Break up the lumps to fist size. Fire on the upper grates only, carrying a bed of uniform thickness over the entire grate surface. Avoid thin or bare spots.

The proper thickness of fire-bed depends upon the intensity of the draft and size of the coal. Lump coal and good draft require a thick fire, say 8 to 10 in., while fine coal and poor draft may render it necessary to reduce the thickness as low as 4 in. Don't let the elevation of the grates at the rear deceive you, but be sure the thickness of the fuel-bed is the same there as at the front.

When slicing, be careful that no green coal falls through to the lower grates. Do not let green coal get to the under side of the upper fire next to the water grates. When slicing push the bar between or along the water grates, and draw it back again without disturbing the fire. Lift the slice-bar just enough to break the caked bed. Use the slice-bar as little as possible. Be very careful not to strain the tubes with the slice-bar.

See that the bed of coal on the upper grates does not get either too thick or too thin. The former will reduce the capacity, and the latter cause smoke.

Do not close the upper doors while fresh coal is on the fires.

Do not reduce the draft by closing the dampers, shutting the fire doors, or otherwise, except when absolutely necessary.

Keep the lower grates well covered, but do not let the bed get too thick, nor permit clinker to accumulate.

Keep the doors between the upper and lower grates closed, except when cleaning lower grates, say, two or three times a day.

Admit a small amount of air under the lower grates, except when they are bare immediately after cleaning.

When cleaning the upper grates see that none of the water tubes are uncovered or exposed. The quantity and location of clinkers can usually be determined by running the slice-bar through the fire. They can then be loosened and hooked out without seriously disturbing the fire-bed. It is better to watch for clinkers closely, and hook them out as fast as they are formed, rather than to attempt a general cleaning of the entire fire bed at one time.

Do not clean the lower grates when there is much green coal on the upper grates. Immediately after cleaning slice the upper grates carefully, so as to get a covering of live coals for the lower grates.

The ashpit should be cleaned as often as is necessary to keep it from filling up and obstructing the admission of air to the lower grates. Never clean the ashpit while the lower grates are bare or thinly covered.

Clean as quickly as possible, so as to avoid cooling the fires.

When cleaning the boilers see that the circulating pipes, and front and rear drums, to which the water grates are connected, are thoroughly washed out under pressure. Those parts which can be examined should be looked into at frequent intervals, and those which can be cleaned by mechanical means should have frequent attention. Where accessible, the water grates should be washed out by inserting a hose into each one.

THE PROXIMATE ANALYSIS OF COAL.*

By S. W. Parr, Professor of Applied Chemistry.

For the purposes of the engineer, especially in boiler tests and relative work, it is necessary to have the data to be obtained by a proximate analysis of the coal and ashes. This includes the determination of moisture, volatile products, fixed carbon or coke, and the ash.

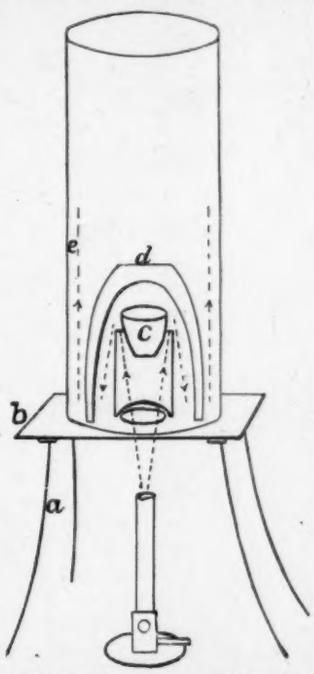
According to the standard methods, the following, in brief, is the outline of procedure: For the moisture, the finely ground sample is dried for one hour in an air bath at 105° to 110° C. For the other constituent, a fresh sample is taken, about a gram in quantity, and in a platinum crucible with the cover on, heated for three and one-half minutes over a Bunsen burner, and followed immediately with the highest temperature of the blast lamp for an equal length of time. The loss in weight, less the moisture obtained, equals the volatile combustible matter. The fixed carbon is next burned off by re-

* From *Technograph*, published by the Engineering Societies of the University of Illinois.

moving the crucible cover and heating in the flames of a Bunsen burner with access of air, till all the carbon is burned off. The loss of weight equals the carbon; the residue is ash.

Owing to the cost of platinum and its rapid deterioration under the conditions imposed, as well as the impossibility of supplying platinum crucibles for extended class work, it became necessary to devise some substitute if possible, and make such modifications as would produce concordant results which conform to those obtainable by the regular method. It was thought that satisfactory results would be obtained with the ordinary porcelain crucibles, provided a sufficiently high temperature, corresponding to that obtained with the blast lamp and platinum crucible, could be reached.

To this end the principles of the Hempel furnace, shown in fig. 1, were adopted, as follows: *a* is an ordinary iron stand or tripod, and resting upon it is the plate *b*, about 10 or 11 American gauge in thickness with a 1½-in. hole in the centre. Over this hole is placed a sheet-iron or fire-clay cylinder or tube having three bearings at the upper edge upon which may rest the porcelain crucible *c*. Over this is inverted an ordinary assayer's crucible *d*, of such size and shape inside as shall allow of free circulation of the hot gases, and having sections cut away at the edge, so as to allow the escape of the gases, thus giving the inverted crucible three short legs on which to stand. Over all is placed the sheet-iron pipe *e*, about 18 in. in height and about 4 in. in diameter, depending somewhat on the size of the crucible *d*. The effect of this arrangement, as may readily be seen from the cut, is to compel the flame and hot gases from the Bunsen lamp to return upon themselves, and so heat the walls and surrounding parts as to prevent radiation away from, but rather direct it toward crucible *c*. The effect further of the chimney *e* is to make a draft and secure a good circulation, this making it easy with proper burner and gas supply to raise the crucible and contents to a heat quite equal to that obtained by the use of platinum and the blast. It should be noted, however, that much depends upon the character of the Bunsen flame. A triple burner giving flames that would reach to a height equal, say, to that of the top of the crucible *c*, proves perhaps the most satisfactory. With proper adjustment of such a burner it is easy to secure a white heat, and this should be accomplished if the results are to be trustworthy. In any event it is well to put the whole apparatus near the edge of the desk, so the crucible can be viewed from beneath and the flames regulated to suit the case. Two necessary variations from the standard method are at once obvious: First, the time element; and, second, the reducing, rather than oxidizing atmosphere, for that part of the operation which burns off finally the fixed carbon.



COAL ANALYZING APPARATUS.

For the first modification it was at first supposed that about double the usual time would produce the same distilling effect as the customary seven minutes with this platinum crucible, but that time gives results somewhat low, unless the parts of the furnace are well heated up before the crucible with the coal is inserted. Repeated experiments, in which time of heating was exactly fifteen minutes, were made and checked by parallel determinations in platinum in the ordinary way with quite satisfactory results, as indicated below. It should be noted especially, however, that the arrangement was such as to easily and readily give to the crucible a white or very bright red heat.

The second modification is necessary in burning off the fixed carbon. Here the use of the furnace is impossible, because an oxidizing atmosphere is essential. The complete Hempel arrangement of parts provides for the conducting into the crucible of a current of superheated air, and it was thought possible to effect the combustion by this means. A more satisfactory way, however, is to remove the outer parts and conduct directly into the crucible a slow current of oxygen from a glass tube of 2 or 3 centimetres internal diameter, or sufficiently large to avoid a jet of gas, the purpose being to avoid carrying away any light particles of ash.

The gas should pass through an ordinary wash bottle, so that its flow may be easily watched and regulated. This method of burning off the coke proves far more expeditious and satisfactory than the customary one of heating the platinum crucible in a current of air. Of course a good flame should strike the crucible, keeping it at a good red heat while the oxygen is being conducted into it, otherwise the process will be a long one. Occasional stirring may expedite matters, but care must be taken to avoid loss. Below are given some results obtained with comparisons by the standard method.

The column marked A gives percentages obtained by the usual method with platinum crucible and the blast lamp. Column B gives the results as obtained by the methods above described:

Coals.	Volatile Matter.		Fixed Carbon.		Ash.	
	A.	B.	A.	B.	A.	B.
Du Quoin	42.06	42.88	44 60	43.72	13 34	13.40
Odin lump	45.38	44.42	42.31	43.20	12.31	12.28
Moweaqua lump	44.17	44.41	42.01	41.62	13.74	13.97
Niantic nut	38.66	38.62	40.55	40.18	20.79	21.20
Odin ash*	15.27	16.52	....	....	....	...
Du Quoin ash	7.77	7.06	....	....	....	....
Moweaqua ash	8.36	8.29	....	..	..	....
Odin ash	14.09	15.01	....	....	....	....
Niantic ash	8.67	7.85	....	....	....	....

THE FUSE FOR THE PNEUMATIC DYNAMITE GUNS.

In previous issues of this paper† we have given descriptions of the pneumatic dynamite guns that have been erected at Sandy Hook, N. J., by the Pneumatic Torpedo and Construction Company for the United States Government, and the tests to which they have been subjected by the Ordnance Board. The wonderful accuracy that was obtained in the tests was a matter of surprise to all who had not carefully followed the development of the guns, and the fact that out of all the shots that were fired there was only one where the charge was not exploded, showed that the fuse was one to be most implicitly relied upon. The fuse and the firing-valve of the gun are the two details about which all of the interest in the mechanism centres. Our readers will recollect the intricacy in the construction of the valve, whereby the admission of the air is so nicely regulated that the impulse given to the projectile is adjusted to an absolute accuracy of range, and how, while the parts act in a prearranged succession, the time interval between the pulling of the firing-lever and the discharge is so short as to be practically inappreciable.

The same care that developed the valve is shown in the design of the fuse that is placed in the dynamite projectile. As in the mechanism of the gun, there were a number of problems to be solved in this connection also. In the first place, the fuse had to be of such a character that the projectile would be perfectly safe to handle after the fuse had been placed in position, and this means that it must be impossible for it to explode the charge. Again, there must not be the slightest danger of the fuse exploding the charge while it is in the gun, else the danger would be far greater to the gunners than to the enemy against whom operations were being conducted. Then, when it comes to the matter of actual explosion, the fuse must be in a condition to fire the charge almost immediately after it has left the gun, and must act upon impact, whether this takes place head-on against an unyielding body, such as the armored sides of a ship, or with a glancing blow, such as it might make against the face of a turret or the sloping curve of an armored deck or in a plunge into a yielding medium like the water. All of these conditions are fulfilled by the fuse under consideration, it being absolutely safe to handle, and exploding instantly upon impact against a rigid body and after a time interval when it strikes the water.

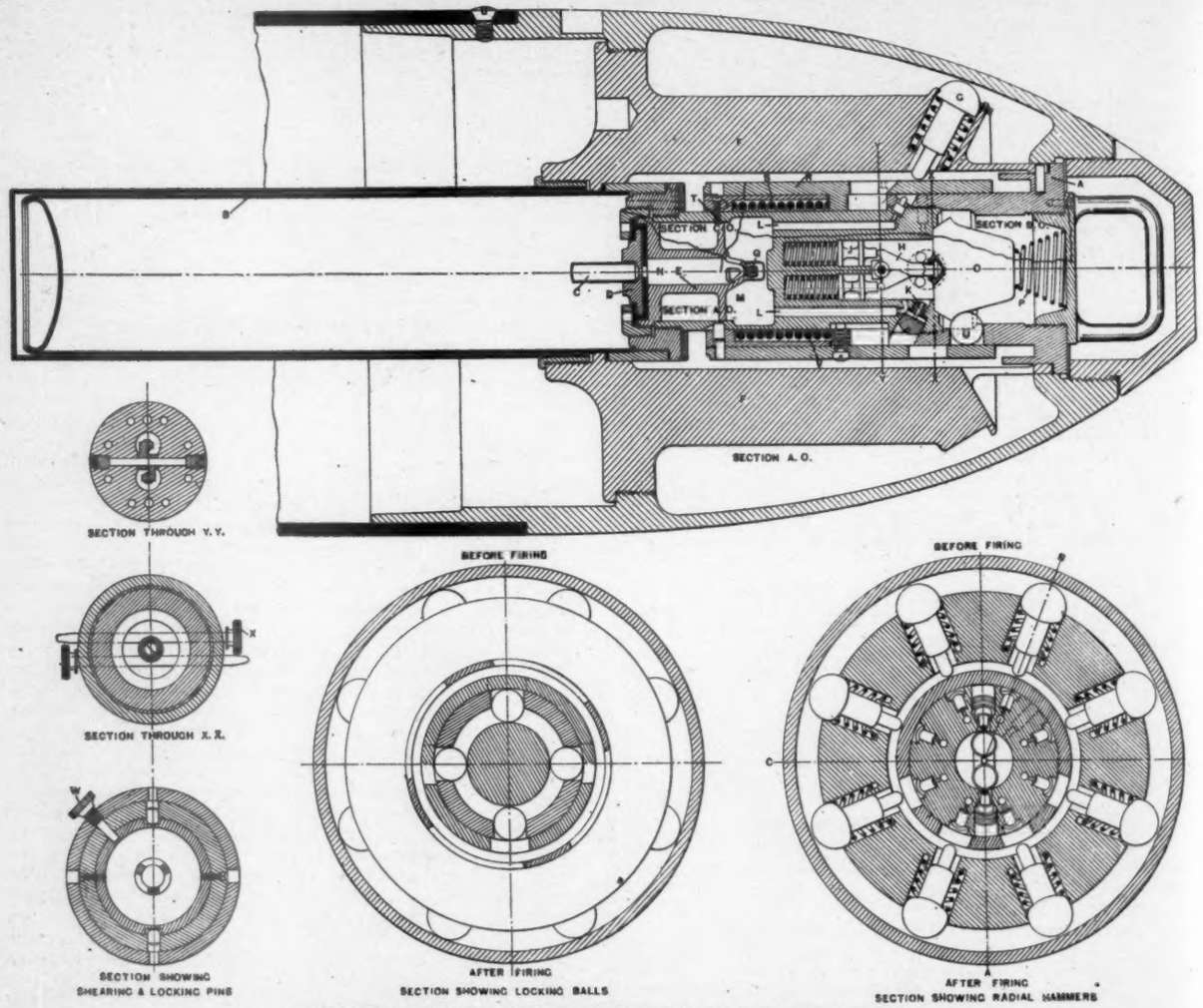
* Taken from the furnace of a boiler that was being tested.

† See American Engineer and Railroad Journal for September, 1894, and April, 1895.

The fuse is of the type known as the trigger fuse, and is inserted at the point of the projectile. The body of the fuse has a length of 11⅛ in. from the end of the detonator to the top of the handle, and a diameter of 3⅛ in. There is a narrow flange at the front end that is screwed up against the projectile, thus forming a bearing to hold the fuse in place. The handle *a* that is shown at the front end is screwed into the fuse, and serves as a cover, as well as affording a means of getting hold of the fuse for insertion and removal. At the rear end there is a brass case, *B*, 12¾ in. long and 3 in. in diameter, that is screwed into the inner end of the fuse and contains 2¾ lbs. of dry gun-cotton for the priming charge.

The detonator consists of the small copper cylinder *C*, 1¼ in. long, ⅜ in. in diameter, and containing 37 grains of fulminate of mercury. It is held by being screwed into a brass washer, and extends into the dry gun-cotton charge. The washer *D*, holding this detonator, is clamped by a brass gland, *E*, between a vulcanite disk and a ring of the same material, in fuse a copper protecting case is screwed into the hammer-sleeve, and thus protects the dry gun-cotton primer.

A better understanding of the action and construction of the fuse mechanism will be obtained by describing the apparatus and then showing its method of action. The explosion of the projectile when it strikes the water is accomplished by means of two spring-actuated hammers *H*, which strike caps and start time trains burning. The two spiral springs *I I* are placed in two circular cavities in the centre of the fuse. They have a force of 90 lbs. and press against circular piston-guides *J J*, that in turn press against the heels of the two hammers *H*. The hammers turn about a common pivot, like the blades of a pair of shears. When these hammers are thrown out they strike against two caps that are located on opposite sides in the interior of the fuse, and are indicated by *K*. Holes *L* are drilled from the nipples in which these are located, and are filled with a slow-burning powder composition. The powder composition is pressed into a brass tube having a length to



TRIGGER FUSE FOR USE WITH PNEUMATIC DYNAMITE GUNS.

order to deaden any vibration. Fire is communicated to the fulminate through the small hole shown at the front end, and which is normally covered with a thin piece of shellaced paper.

An important *rôle* in the action of the fuse is played by the head of the projectile itself. It is made of cast bronze and ½ in. thick. On the inside of the head there is a bronze casting, *F*, called the hammer-sleeve, which is secured to the head by a screw-thread. This hammer-head contains the fuse and carries eight radial hammers *G*, which stand at an angle of 60° with the axis of the projectile, and are pressed against the interior surface of the head by spiral springs, as shown in the engraving.

The head is made thin, so that it will crush in or collapse when the projectile strikes a solid object. The end of the hammer-sleeve *F*, which extends into the point of the projectile, is also made quite thin so that it will collapse under any blow that crushes the head. Finally, at the rear end of the

give the desired delay, and this tube fits tightly into the channels, which are ⅛ in. diameter holes *L* drilled in the body of the fuse parallel with its axis. From the time train fire is communicated to the detonator by a flash charge of flocculent dry cotton and of quick-burning rifle powder, these fill the two chambers *M* and *N* respectively between the detonator and the ends of the time trains.

Normally the two hammers are held from striking the caps by their ends entering a cavity in the face of a circular truncated metal piece, *O*, termed the trigger. This rests against a narrow circular seat, and is held in place by a conical spiral spring, *P*. Until the fuse is fired from the gun the trigger is positively locked in place by four steel balls. When these balls are removed the trigger is free to move forward and trip the hammers, when the projectile is retarded enough to cause the inertia of the trigger to overcome the force of the conical spring holding it in place; as, for example, when the projectile enters the water. By making this spring strong or

weak the sensitiveness of the fuse can be adjusted within desired limits. The energy required to fire the caps is stored up in the two compressed springs *I I*, and the trigger has only to release this energy. In many earlier forms of fuses the blow of the ball or plunger, similar to this trigger, was used to fire the caps, and with heavy projectiles and a necessarily light ball a very considerable retardation of the projectile was required to fire the cap, and this could not be obtained in the case of projectiles striking the water at a low velocity. This, then, is considered to be the most novel feature of the fuse. Because it can be made so extremely sensitive it does not necessarily follow that it need be so, for by simply making the trigger spring very stiff it becomes very insensitive. Furthermore, it does not follow that because the fuse is sensitive it is dangerous to handle. Under all conditions of handling the trigger is positively locked, making it perfectly safe. Another feature of this hammer and trigger arrangement is the fact that it will operate no matter how the projectile strikes, even though it strikes on its side. This is due to the fact that the centre of gravity of the trigger is far in advance of its seat, and that the chamber in which it is contained is large enough to permit of a sufficient side movement to trip the hammers.

Should the projectile strike point blank against a solid object, the head will collapse and in turn collapse the fuse at this weak section, firing the cap *Q*, which communicates directly by a flash channel with the fulminate detonator, thus causing instantaneous explosion. The time trains would be ignited at the same time, but the projectile would explode before they could burn out.

To provide for an explosion in the case of the projectile striking a glancing blow, there are eight firing-pins covering caps and in line with the eight hammers *G* held in the hammer-sleeve. Flash channels lead from each of these caps directly to the fulminate detonator. When the projectile strikes a glancing blow, a hammer will be driven against the firing-pins, either by the crushing of the head or by rebounding from the interior of the head, causing instantaneous explosion. The springs under the hammers are made sufficiently stiff to prevent the hammers from striking the firing-pins and causing an instantaneous explosion when the projectile strikes the water.

It will be readily seen from the foregoing that the fuse is in a condition to explode upon suitable provocation after the projectile has been fired, and it now remains to show how it is rendered perfectly safe to handle before firing. This is accomplished as follows: A sleeve, *R*, fits the outside of the fuse body and has a limited motion parallel with its axis. To prevent its revolving around the fuse, the point of a screw guides it by running in a slot. There are eight holes in this sleeve corresponding with the eight-side hammers *G*, and four holes corresponding with the four balls *U* that lock the trigger. Within this sleeve there is a shorter sleeve, *S*, and a stiff spiral spring, *V*, between the shoulders of the two tending to separate them. Before the projectile containing the fuse is discharged from the gun, the two sleeves are secured together by double pins with a joint in each. The sleeves are fastened to the body of the fuse by two small shearing screws. Before firing the long sleeve is in a position to cover the eight firing-pins, making it impossible for the side hammers to strike them, and in position to hold the four balls in place that lock the trigger. When the projectile is accelerated along the bore, both sleeves, after breaking the two shearing screws, move rearward against a babbitted seat. This rearward motion is about $\frac{3}{4}$ in., and it causes the two jointed pins that have secured the sleeves together to be pushed outward by sliding up an inclined surface, until the joint in the pins coincides with the joint between the two sleeves, thus releasing all connection between them. So long as the projectile is being accelerated in the bore the sleeves remain in their rear position, but when the acceleration ceases, as the projectile leaves the muzzle, the outer sleeve is moved forward by the force of the spiral spring acting against the shoulder within it. Its motion is somewhat retarded by an air dash-pot into which its front end enters. It finally comes to rest in its forward position when the projectile has gotten well away from the gun. In this position the eight firing-pins are uncovered to the side hammers, and the four balls that lock the trigger are free to drop or be thrown out by the centrifugal force of the revolving projectile, thus unlocking the trigger.

In order to give additional safety in handling the fuse before it is inserted in the projectile, a screw, *W*, with a large milled head is put through both protecting sleeves into the body of the fuse, and two long pins *X X*, also having milled heads, are put through the fuse in a position to hold the hammers from striking the caps when the trigger is removed. The heads of this screw and the two long pins are so large that they must be removed before it is possible to enter the fuse into the projectile, thus making it impossible to leave them in the fuse by mistake.

The fuses are packed in hermetically sealed tin cases, and six placed in a wooden box lined with felt. A box of tools is also provided for charging, testing, and assembling the fuses.

The mechanism of this fuse, like that of the valve of the gun, was worked out by Captain Rapieff, who is the Chief Engineer of the Company, and the whole apparatus is a fine example of ingenuity and effectiveness.

WATER-TUBE BOILERS.

M. J. A. Normand, the well-known French engineer, recently read a paper on this subject before the Institution of Naval Architects, from which we make a few abstracts. He opened his paper with the frank acknowledgment that water-tube boilers are inferior to the ordinary marine type, in that any damage to any one tube necessitates drawing the fire and emptying the boiler, but claimed for them an immense advantage on account of their lightness and their capability of supporting an intense firing. This latter is limited by the formation of steam chambers or stationary steam, whereby the metal is apt to become overheated and rapidly corroded by the oxygen in the gases on the outside and the steam on the inside. Such conditions may, however, be avoided by having the direction of the tubes, especially at the lower end, as vertical as possible; by an active circulation; by having the proportion of length to diameter not too great, and by having the return section of the outside down-take of ample proportions.

In order to prove these propositions, a reference was made to the Du Temple boiler, shown in fig. 1. The oldest form of large boilers is shown at *A*, and the later at *B*, for the sake of clearness only one tube being shown in each. The heating surface of the two designs was kept the same by increasing the number of tubes in *B*.

Regarding the necessity of having the tubes in as nearly a vertical position as possible, it will be seen that an intense heat applied to the parts *m m* will produce steam which may take one of two courses: It may rise to the upper reservoir or go down to the lower one, or it may divide and go in both directions. In the first case, although the rise in the upper portions will produce a very energetic circulation, the resistance to an upward motion is very great, while in the second the resistance is small, as the pressure in the lower reservoir is always less than in the upper. When firing is slow the circulation may be in the right direction, but when the fires are forced or the vessel heels the contrary may be the case; for this reason the arrangement in *B*, where the angle with the horizontal is much greater, gives better results.

That the circulation should be very active is supported by laboratory experiments, by which it is shown that the coefficient of the transmission of heat varies from one to five, according as the motion of the water is *nil* or very great.

The section of the down-take should be large, because when the boiler is at work the pressure in the inferior reservoir is always less than in the upper. Should it be otherwise, the water would not flow by the return tubes. It is most probable that the steam generated in the heating tubes produces the circulation of water by impulse only. This force of impulse is so great, that when the tube is vertical, the ascending motion of the fluid may be estimated by applying the theory of communicating vessels, according to the difference between the mean density of the heterogeneous fluid in the heating tube and that of the water in the return tubes, due allowance being made, of course, for friction.

In this one thing is indisputable, and that is that the rise of water and steam in the heating tubes produces a difference of pressure between the upper and the lower reservoirs, and this difference reduces the intensity of the circulation. Accordingly it is of the utmost importance to lessen this difference by giving to the return tubes the greatest possible section.

The second cause which limits the intensity of the firing is the strains due to the expansion of the heating tubes, for the prevention of which there are several methods; but it is most important that there should be no joints or riveting in the actual vicinity of the furnace.

I have alluded already to laboratory experiments, according to which the coefficient of the transmission of heat varies from one to five, according as the water to be heated is quite stationary or in rapid motion. This is easily accounted for by this fact, that water is a very bad conductor of heat, and can be heated only by putting all the particles successively in contact with the heating surface. Although the actual conditions of a boiler are very different from those of the experiments, especially as regards the temperature of the heating

fluid, it is not less true that active circulation in boilers is most favorable to vaporization. This explains how the advantage to be derived from the use of feed heaters is always superior to that which results from the economy in the units of heat saved. This is especially to be noticed with Mr. Kirkaldy's feed heater. In this apparatus steam taken from the boiler heats the feed before its introduction into the boiler. The result is evidently to equalize, in a great measure, the temperature of the water and steam contained in the boiler with no apparent, though with an undeniable economy. The phenomenon may be explained as follows: When the water enters the heating tubes it travels without boiling through a certain length of those tubes; the lower its temperature is below that of the steam, the longer this distance; and, since the circulation is caused by the development of bubbles in the tubes, the intensity of the circulation is reduced as this difference of temperature increases.

For the last two years I have obtained the same result in the most simple manner by introducing the feed in the steam space under the form of spray, as far as possible from that part where the steam is taken for the engines. The feed being already heated by steam having done work in the high-pressure and medium-pressure cylinders, there is scarcely any difference of temperature between the water and the steam in the boiler. As soon as the water enters the heating tubes

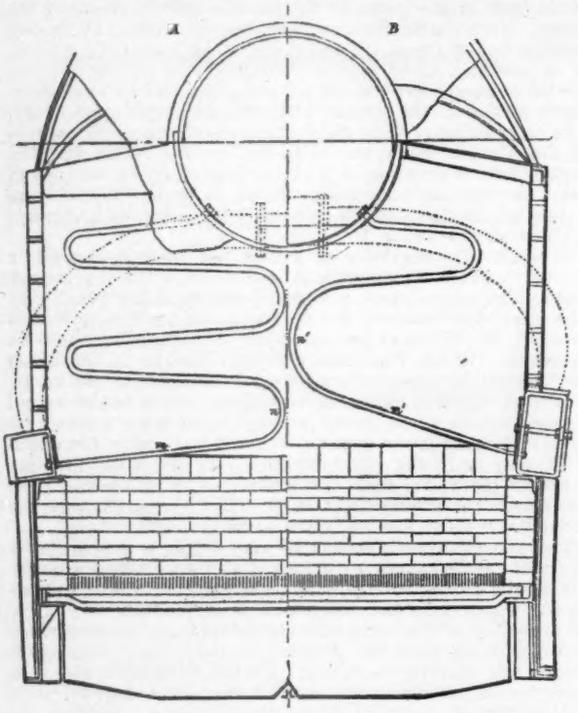


Fig. 1.

bubbles of steam are produced, and the circulation is increased to such a rate that the temperature of the tube is not higher than with cold feed. This mode of introducing the feed, which has the further advantage of depositing the calcareous salts in the form of powder, when using sea water, requires some very simple but particular arrangements in order to avoid shocks in the feed-pipes.

The temperature of the products of combustion would be enormous and greatly superior to that at which the dissociation of carbonic acid and steam takes place, if it could be completed in the fire-box. Starting from this undeniable fact, some engineers think that the heat should be progressively subtracted by cool surfaces during the combustion of the coal. This is certainly not the case. No cooling should take place during the combustion of petroleum, which cannot give its total heat unless it takes place in a white-hot refractory receiver, where it is impossible to avoid dissociation. The use of the brick arch in locomotive fire-boxes has proved equally advantageous for the complete combustion of coal, especially coal rich in hydrocarbons. For the same reasons it is most important to have high and large fire-boxes, where the hot gases are well mixed, and remain as long as possible before entering the cluster of tubes.

With a given capacity of boiler, the section of passage may be very great and the length of travel very small, or the section may be very small and the travel very long, with all intermediate proportions between these extreme limits. In the first case the draft is good, but the heating surface is very seldom thoroughly utilized. In the second case a good air pressure is necessary, but the economic duty is better, because the hot gases are obliged to heat the whole of the heating surface, and because the transmission of heat increases with the agitation of the gases, as it does in the case of water. This was proved a great many years ago by some most important trials made in France by Mr. Geffroy, of the Northern Railway of France, on a locomotive boiler. The evaporation was measured, first with all tubes open, and second with half the tubes only. In the last case, notwithstanding the enormous reduction of heating surface, the evaporation per pound of coal remained the same, with this difference only, that a greater air-pressure was necessary. The conclusion to be derived is that the section for the passages of the hot gases should be reduced, and their travel lengthened as much as is consistent with the draft available. The rules given above are certainly not the only ones necessary for making a good water-tube boiler, intended to resist intense firing, but they are certainly the most important. In order to avoid all misunderstanding, I will show how they have been applied in Normand's boiler. My intention is not to make known an apparatus that has already been many times tried in France and abroad, but I have chosen it because I believe it embodies more completely than any other the above principles.

In general appearance (see fig. 2) the boiler is the same as that used in 1893, but the arrangement of the clusters is new, and has been applied on the three torpedo-boats lately delivered. This arrangement gives a higher economic duty than the former one.

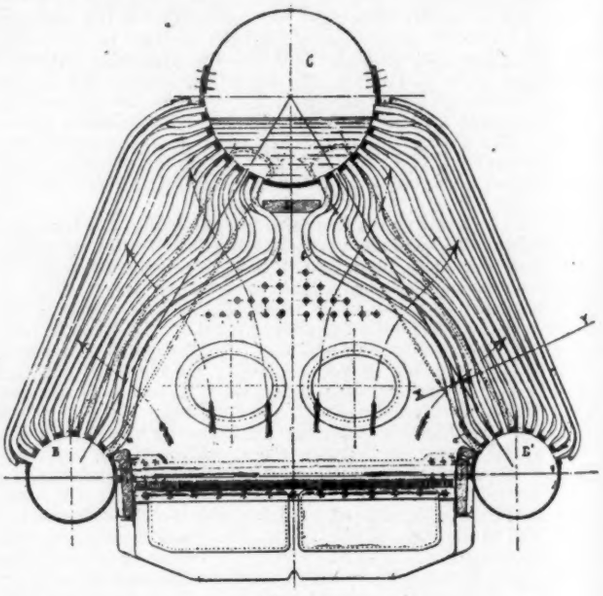


Fig. 2.

The particulars of the boiler are:

Grate surface	39 sq. ft.
Heating surface	1,840 sq ft.
Number of tubes	1 284
External diameter of tubes	1⅜ in.
Internal " " "	1 in. bare.
Pressure	299 lbs. per sq. in.
Weight with all valves, bricks, fittings, etc., without water	10 tons, 9 cwt.
Total weight with water	13 tons, 2 cwt.

In No. 185 (single screw) the power of the engine was measured and found to be, at the official full-speed trial, 1,680 I.H.P.

Air pressure	3½ in.
Consumption of coal per hour	2,600 lbs.
" " " " per sq. ft. of grate	67 lbs.
" " " " " indicated H. P.	1.56 lbs.
Indicated H.P. per sq. ft. of fire grate	43 lbs.
" " " " " heating surface	0.91 lbs.
Mean temperature of feed	241° Fahr.
" " " gases in funnel	708° Fahr.

The fire bars were too close; more air will be admitted in future. At 14 knots the consumption of coal is under 1 lb. per I.H.P. per hour.

As indicated by arrows, the hot gases enter, on both sides of the boiler, the cluster of tubes L at the front end only, and through the whole height. They afterward travel horizontally to the other end where the funnel is situated. An in-

verted bridge, pierced with small holes, forces the gases to heat the lower part of the tubes before entering the funnel. Otherwise the upper part only would be heated. The general direction of the tubes, especially in the more heated part, is such that bubbles of steam will rise easily, and that none of the steam produced can return to the lower reservoirs. The height of the fire-box is very great, and the greater part of the flames and hot gases remain a long time in it, being obliged to come to the front before entering the cluster of tubes. The motion thus imparted to the flames is favorable to complete combustion. The ratio of length to inside diameter in the longer tubes is 68, whereas in the former type A, of Du Temple boiler, it was 160 and 320 in type B. The curves of the tubes are sufficient to prevent any undue strains from expansion. The diameter of the three return tubes is such that the difference of pressure between the upper and lower reservoirs must be very small. In boilers now building at my works, the return tube at the funnel end has been dispensed with. The section of passage of the hot gases is not so large that any part of the heating surface could be left out. Their length of travel is great, and their motion being perpendicular to the axis of the tubes, is favorable to their agitation, and consequently to the transmission of heat. On the other hand, it requires a higher air pressure. Should a better draft be found necessary, the width of the clusters of tubes might be increased.

The upper end of the tubes is under water, and the shape of the tubes is such that the formation of "steam chambers" is impossible. Water circulation begins as soon as the fire is lighted. It becomes intense at full power. When the vessel is laid up, the boiler may be completely filled with pure water saturated with lime. No air can remain in the tubes. This is of great importance as regards durability. It is indeed difficult to see why the firing could not be increased from what it was in the trial above mentioned if the tubes only are taken into account. From my own experience, it is the durability of the fire bars and bricks which limits the intensity of the fire.

Objections have been made about the necessity of removing several tubes should one middle tube be damaged. The quality of mild steel tubes is such that they may be taken out and replaced without the least difficulty. No better proof can be given of the feasibility of this plan than the following: The three boilers of Nos. 183, 184, and 185 were finished, when it was decided to alter the arrangement of the clusters, according to the new design. With very simple tools, hundreds of tubes were removed and replaced after having had their shape altered, without any of them being damaged.

Most of the principles laid down in this paper may appear to be so simple as to render their statement useless. It is not so, if we consider how very few of the different types of water-tube boilers are designed in accordance with all of them. However, my object is not to criticise any of these types, when not intended for intense firing, although the best boilers for intense firing are also generally the best for slow work. Many water-tube boilers are now making steam with tubes nearly horizontal, very low fire-boxes, great section of passage, and short length of travel. Each can boast of particular advantages which cannot be disputed. But the conditions imposed for boilers become more and more severe. In order to save weights, the combustion of fuel per square foot of grate increases every day; 20 lbs. is no longer sufficient, twice, perhaps three times as much will soon be expected for the most powerful engines. A good design will give the owner, the engineer, or the navy that adopts it a great advantage. It is worth while to examine how it will be possible to meet impending exigencies.

PERSONALS.

MR. R. R. HAMMOND has been appointed Division Superintendent of the Kansas City, Fort Scott & Memphis Railroad, and will have charge of the division extending from Springfield to Mile Post 481 and also the Current River Railroad.

MR. T. A. MILLER has been appointed Assistant Superintendent of the Greenfield & Northern Railroad, which has recently been acquired by the Kansas City, Fort Scott & Memphis Railroad, and has been made a division of that road.

MR. W. W. FAGAN has withdrawn from the service of the Kansas City, Fort Scott & Memphis Railroad, and the office of General Superintendent has been discontinued.

MR. J. H. EMMERT has been appointed Superintendent of the Kansas City, Fort Scott & Memphis Railroad, and as such will have charge of all transportation, also of the repairs and maintenance of buildings, and the repairs and maintenance of road, track, and bridges under the general direction of the Chief Engineer. His office will be in Kansas City, and his authority will extend over the Kansas City, Clinton & Springfield Railway, the Current River Railroad, and the Greenfield & Northern Railroad.

OBITUARIES.

Alban Nelson Towne.

ALBAN NELSON TOWNE, Second Vice-President and General Manager of the Southern Pacific Company, died suddenly in San Francisco recently. Mr. Towne was born in Charlton, Mass., on May 26, 1829, and entered railway service in 1855 as a brakeman on the Chicago, Burlington & Quincy Railroad. He was advanced rapidly, and in 1867 was General Superintendent of the Chicago & Great Eastern Railway. He was subsequently appointed Assistant General Superintendent of the Chicago, Burlington & Quincy, but left that road in September, 1869, to become General Superintendent of the Central Pacific Railroad. He has since remained in the employ of the Huntington roads, and was elected to the position he filled at the time of his death on April 9, 1890. He married on September 25, 1850, Miss Caroline Amelia Mansfield, of Webster, Mass.

Henry Lefferts Brevoort.

HENRY LEFFERTS BREVOORT, a member of the old Brooklyn family of that name, died at his summer residence at Rockaway Beach on July 5, in his forty sixth year. He was the only son of J. Carson Brevoort and Elizabeth Dorothy Lefferts. The Brevoorts were descendants from an old Dutch family who settled on Long Island many years ago. They owned a farm there, which in late years has become part of the city of Brooklyn.

Mr. Brevoort was a man who inherited wealth, but to whom a life of idleness had no attraction. He early developed a fondness for mechanics, and before he was twenty-one years old he attended the Stevens Institute in Hoboken, and afterward formed a copartnership, and for a few years was engaged in machine business. He was of an inventive turn of mind, and brought out several new devices. Later he devoted himself to mechanical engineering, and was associated with Richard Buel, whose mysterious disappearance a few years ago was the cause of so much grief to his friends and relatives, and of whose fate no information was ever obtained. Later Mr. Brevoort became associated with his cousin, the late Henry Brevoort Renwick, a noted patent lawyer and expert. This relation led Mr. Brevoort to adopt the profession of a patent expert, in which he afterward acquired great distinction. Within the last twenty years few patent cases of importance were tried without his being retained by one party or the other. He was a prominent expert witness in such cases as the electric patent for telephony, phonographs, telegraphs, lamps, air-brake, and railroad machinery.

He was a member of the Union League Club of Brooklyn, a director in the Brevoort Savings Bank, and a member of a number of scientific societies.

Besides his professional acquirements he was a charming friend and companion, with a most attractive and genial character and manner, which made for him many friends, to whom his death is a sad loss, and a cause of sincere sorrow.

In 1883 he married Miss Gertrude Lefferts, a daughter of John Lefferts of Flatbush. She survives him. He also leaves three sons, John, Carson, and Henry. Mr. Brevoort was a member of the Church of the Pilgrims, and the Rev. Dr. R. S. Storrs officiated at his funeral.

Manufactures.

THE IDEAL RESAW.

WITH the destruction of our forests and the increased cost of timber in general, the item of waste, which was formerly entirely overlooked, has attracted a good deal of attention.

The workers in wood are now using machinery of improved patterns in all branches in order to manufacture as economically as possible, and one of the greatest economizers in woodworking is the band resaw. These have now become so perfect, that saws as thin as 26 gauge, or eighteen one thousandths of an inch in thickness, are actually used in sawing some classes of material, such as veneer, picture backing, and other thin

material, where the saw kerf would ordinarily constitute a large percentage of the timber worked.

W. B. Mershon & Company, of Saginaw, East Side, Mich.,

THE IDEAL RESAW.

owning one of the most extensive woodworking plants in the country, realized the necessity of a perfect resaw and designed the E. C. Mershon band resaws, one of which, the Ideal, is illustrated. Knowing what would be required of such a machine, they have provided all adjustments and attachments which are necessary, and in designing this resaw it has been with a view to using the thinnest saw possible. The saw blade on a machine of this description is the same as a main-spring of a watch, and the proportion of all the working parts has to be considered with reference to it.

In connection with the upper wheel all extra metal must be dispensed with, and the most sensitive cushions and springs provided for giving the right tension. The Ideal Resaw is so skilfully made that it is possible to manufacture from 1-in. timber four pieces which, after resawing, would measure in the aggregate $\frac{1}{8}$ in. This, as will be seen, leaves only $\frac{1}{8}$ in. for three saw kerfs and planing eight times.

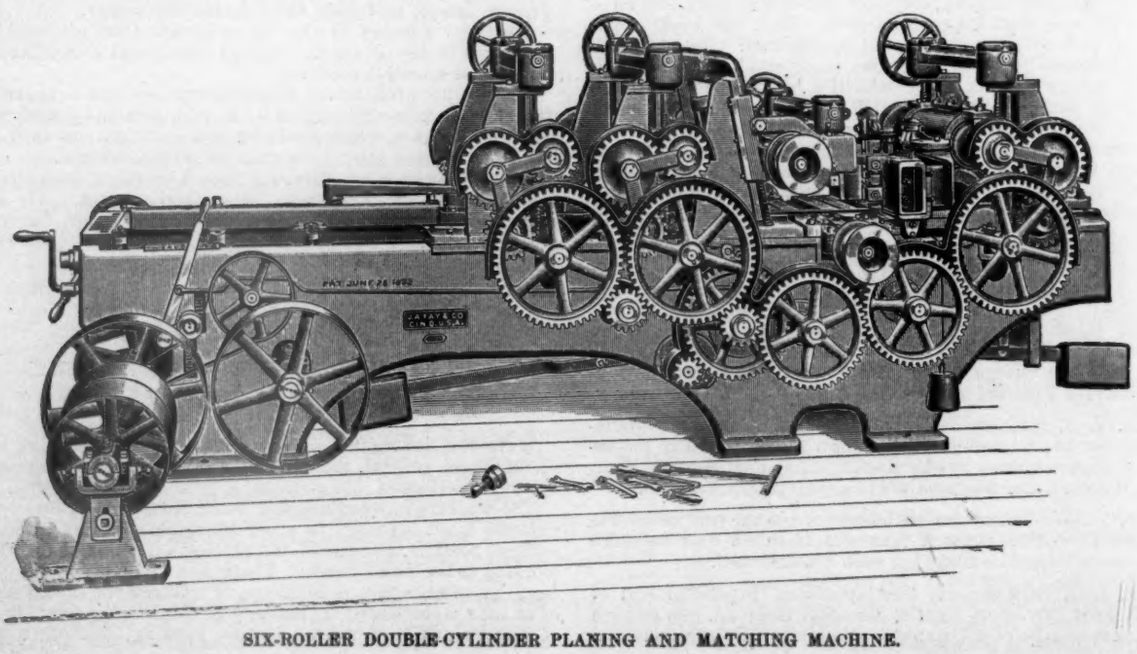
That these resaws represent wonderful advance in this line of work is evidenced by the fact that while they have only been on the market three years 100 of them are now in actual service. They are recognized as standard, not only in this country, but abroad.

NEW LARGE SIX-ROLL DOUBLE-CYLINDER PLANING AND MATCHING MACHINE.

THE machine shown in the accompanying illustration is the largest and heaviest planing and matching machine made by J. A. Fay & Co., Cincinnati, O., with special reference to durability, convenience, rapidity and the general requirements necessary to economy of labor and the superior quality of its productions. The machine is made in three sizes, to plane two sides up to 24 in., 28 in. and 30 in. wide and 10 in. thick, and match or joint material up to 18 in., 22 in. and 24 in. wide respectively.

The framing is massive and perfectly fitted and bolted together to secure the requisite solidity. The journals, shafts, gears, screws and bolts are made to standard sizes, and, with a system of interchangeable parts, enables duplicate parts to be supplied on short notice.

The cylinders are made from forged steel and are slotted on all four sides. The journals are $2\frac{7}{16}$ in. in diameter and are lead ground. The bearings are exceptionally long, and after being lined with the best material procurable, are scraped to a perfect fit. The upper cylinder has its bearings yoked together from above and planed to fit cored uprights cast to a solid bed plate and bedded in a groove which always retains them in line. These yoked bearings carry the pressure bar over the lower cylinder, which, while also having an independent adjustment, rises and falls with them. This pressure bar, after being set to suit the cut of the lower cylinder, requires no other adjustment for any variation in the thickness of the cut—an important item in a machine provided with a power-raising attachment. The lower cylinder runs in a



SIX-ROLLER DOUBLE-CYLINDER PLANING AND MATCHING MACHINE.

heavy frame, adjustable to suit the cut, and has pressure bars on each side of it.

The power-raising attachment is so arranged that the upper cylinder and feed rolls can be raised or lowered together, or that they may be instantly thrown out of gear and any desired adjustment made by hand. When the upright lever shown is thrown forward it unlocks the upper cylinder and tightens the belt operating the raising attachment, and another lever on the end girt, convenient to the operator, throws the friction in and out and raises or lowers the cylinder and rolls as the lever is thrown one way or the other. A gauge is placed on top of the side frame in a position to be easily read by the operator. Suitable stops are provided to prevent accidents arising from the cylinder and rolls travelling beyond a safe point. Ball bearings are placed under the upper cylinder screws, rendering them easy of adjustment by hand when desired.

The matching works are of the most substantial character. The arbors, of steel, $2\frac{3}{16}$ in. in diameter and $1\frac{1}{4}$ in. where the heads are applied, have each three bearings, one of which is placed at the top of the spindle, which can readily be removed for changing the heads by simply removing one bolt.

The weighted matcher clip with steel chip breaking lip—invaluable for working cross-grained or knotty lumber and producing rapid and accurate work—is hinged to the matcher hanger and a uniform pressure maintained by means of the weight. Regular matcher heads of gun metal with steel screws and patent solid milled matcher cutters or shimer matcher heads are furnished with the machine, as may be ordered.

To prevent shavings produced by the side cutter from being scattered over the machine, to the annoyance of the operator, shaving hoods are fitted to each hanger about the cutter heads, to direct all shavings away from the machine. These hoods are convenient in attaching exhaust pipes for the removal of the shavings by means of an exhaust fan. Pressure dogs are placed after the cut of the matcher heads to hold the material firmly while being matched. It is important to notice that the matching works are placed after the lower cylinder, the material thus being brought to an even thickness before being operated on by the side cutters.

The feed worms consist of six rolls 7 in. in diameter, and with large journals, one pair, placed after the matcher works, keeping the board in a straight line and feeding it entirely away from the machine. The feed rolls, mounted on planed upright stands, are fitted with socket joints and connected at each end by heavy expansion gearing with double or outside links, and are heavily weighted. The weighted levers are inside the machine and move with perfect freedom. The feed of the machine is very powerful, the rolls being large, and the belting, gearing and weighting being so proportioned as to allow no slipping. The front platen has two rollers in it to relieve the heavy timbers of friction, and this platen is arranged to admit of using the regular arm for holding the material against the guide, or a wooden lever as preferred.

Ordinarily two rates of feed are furnished with the machine, 41 ft. and 56 ft. per minute respectively; but other speeds are provided if desired.

Each machine weighs 15,000 lbs., and there is a shop number attached to it and a number on each casting to identify them, which should be mentioned in ordering supplies. The countershaft has tight and loose pulleys 16 in. × 10 in., and should make 1000 revolutions per minute.

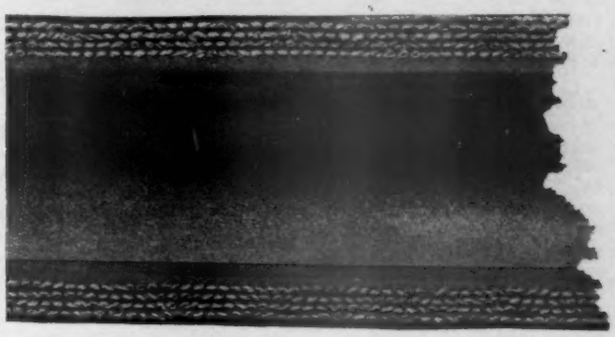
RUBBER HOSE.

In heating cars by steam and in the operation of air brakes, flexible hose is required to conduct the steam or compressed air from the engine to the train and from one car to the other. Experience very soon taught those who had charge of the heating apparatus and air brakes of railroad trains that the rubber hose which was used for that purpose deteriorated more or less rapidly from use. They also learned that there was very much difference in the durability of various kinds of hose, and that its lasting properties depended very much on the qualities of the materials of which it is made.

Hose for conducting steam and compressed air consists of several layers of heavy cotton canvas—usually four or five, as shown by the section herewith given—to give it the requisite strength. This canvas is covered inside and outside, and also between its layers, with a coating of vulcanized india-rubber to make it air or steam-tight. Both the canvas and the rubber must of course be flexible. The strength of the hose to resist internal pressure is dependent almost entirely upon that of the canvas used. If this has not the requisite strength, the hose is liable to burst. Its steam tightness—to coin a phrase—is dependent upon the coatings of rubber—chiefly upon that on the inside. This, too, must of course have great flexibility. While pure india-rubber, in its natural state, is very flexible, it has little power to resist heat, and very soon becomes softened when exposed to comparatively low temperatures. To give it heat-resisting properties it is vulcanized, as it is called—that is, it is mixed with mineral substances, chiefly sulphur. These alone have no flexibility, and are liable to crack and disintegrate when exposed to heat and constant flexure. In order that such hose may be durable, then, three things are requisite: (1) the canvas of which it is made must be strong enough; (2) there must be enough pure rubber in the internal and external lining to give it flexibility; (3) the rubber must be properly vulcanized to resist heat.

The most expensive material used in making hose is the pure rubber; the next is the canvas. There is, therefore, a constant temptation to manufacturers—under the stress of competition—to use as small a quantity of pure rubber as possible, and next to use a cheap or inferior quality of canvas. It may be said that the minerals which are compounded with the pure rubber have alone little capacity to resist heat and flexure combined. When subjected to both, they are speedily disintegrated. There is a proportion in which pure rubber and mineral substances may be combined which will give the maximum capacity to resist heat and flexure. As minerals are cheap and rubber is dear, the reader can judge which the manufacturer is most likely to add in excess. Under the stress of competition he is likely to add more and more mineral substances, or a cheap quality of rubber, to reduce cost, and rapid deterioration of the hose made of such materials follows.

Of course a great deal of skill and experience is required in the manufacture and compounding of the materials used in making rubber hose, but back of these a certain amount of integrity of purpose is of the utmost importance.



SECTION OF HOSE MADE BY THE PEERLESS RUBBER MANUFACTURING CO.

The practice of winding rubber hose with wire to protect it from abrasion and to fortify its strength is condemned by some manufacturers. The canvas alone, if of the right quality, should be sufficiently strong to resist any internal pressure to which the hose is subjected. When hose is exposed to the heat of steam the material of which it is made is softened and also expands. If it is wound with wire the hose cannot expand outwardly, and its movement must therefore be inward. The result is that the inside diameter of the hose is contracted.

The use of wire in wrapping hose is to be deplored, particularly if steam is employed, from the fact that hose, when conducting steam, softens at least 25 per cent., and it also has a tendency to expand the hose. It is a well-known fact that couplers require an exact length of hose on many of the roads, and the complaint is that their hose *grows* too short, which is owing to the expansion of the hose. Many of the manufacturers and railroad companies have decided to overcome this expansion by wrapping hose with wire. The result is that while the hose does not expand much and contract in length, it must move somewhere, so it goes in the only direction which is left—in other words, it swells the inside of the tube, eventually choking up the inside diameter of the hose completely.

Another effect is that when steam is passing through the hose both it and the wire are heated, and the rubber is to some extent softened. When steam is turned off, the wire, being on the outside, and being a better conductor of heat then rubber or canvas, it becomes cooled first, and consequently contracts and is indented or pressed into the rubber. From the repetition of this disintegration occurs in time, and the hose is also chafed by the hard, unyielding material of the wire.

Another fact should be noted here, which is that the strength

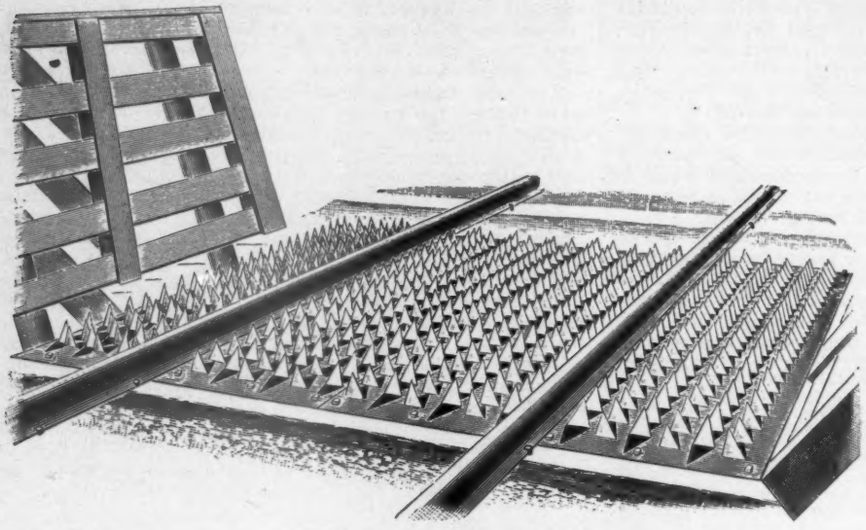
of hose to resist internal pressure is dependent chiefly upon the canvas of which it is made. This may be coated with a poor quality of rubber, which will soon crack and disintegrate, while the hose when new may resist a very great pressure. Of course all hose should be sufficiently strong to bear the pressure which it must resist, but beyond such limits its strength is not of much importance. For instance, if it is decided that air-brake hose should stand 700 lbs. per square inch, it would not add to its durability if it were capable of resisting from 900 lbs. to 1,200 lbs. pressure. Very strong hose may be coated with a very poor quality of rubber, and therefore would last only a short time.

In another part of the paper there are some illustrations given by the Peerless Rubber Manufacturing Company, showing the duration of some kinds of hose in service, and the deterioration of others under similar circumstances. These illustrations will give some idea of the difference in the quality of the materials of which hose is made. The notes under each engraving indicate the service of the different specimens, and also that in buying such material something else besides the price should be considered.

THE SHEFFIELD CATTLE-GUARD.

FROM the time that George Stephenson announced the fact to the parliamentary committee that a collision between a railway train and a cow would be very bad for the "coo," railway managers have adopted every precaution to prevent such collisions and the consequent damages that an unsympathizing jury would be sure to inflict when the case came to trial. At first the idea was prevalent that a hole in the ground would accomplish the purpose; but the notable cow that jumped over the moon seemed to have many descendants in the neighborhood of railway tracks, and the hole in the ground merely served the purpose of giving these animals a little healthy exercise, so that a desirable substitute had to be looked for.

In the next place, this hole in the ground was an undesirable feature in the landscape of the railroad and a continual expense to maintain. Something that could be laid upon the ground was the thing, and yet, at the same time, it must be of such a character that it could not be crossed by wandering cattle, while its durability must be such that the elements would have no effect upon it. These surface guards, as they are called, have had a large sale—so large, in fact, that they have entirely supplanted the holes in the ground, and the spirit of the roadmaster is now vexed by the necessity of making a choice. Our illustration shows a new candidate for the favors of the railroad buyers, and from an inspection of the engraving it would certainly seem that the way of transgressing cattle would be hard if they attempt to traverse this obstruction. It is formed of four sheets of steel boiler plate in which sharp teeth are stuck up very close together over the entire surface, presenting an area that reminds one of the hard road to travel—so hard, in fact, as to be about impassable. As brevity is the soul of wit, so simplicity is the soul of a successful mechanism, and here this seems to obtain. There are no rods or bars to be broken or displaced and the track needs no preparation whatever in order that it may be put in place. It cannot fail to be durable, and its weight is a warrant that it will make no noise when a train passes over it. The standard style is furnished with a coating of asphaltum paint, or the sheet may be galvanized, as the purchaser may prefer.



THE SHEFFIELD CATTLE-GUARD.

It is made by the Sheffield Car Company, of Three Rivers, Mich., and has already been adopted by a number of railroads as their standard cattle-guard.

TEST OF A RICHMOND LOCOMOTIVE WORKS COMPOUND ENGINE ON THE ROCK ISLAND RAILROAD.

THE following interesting report of the performance of a 10-wheeled compound, in comparison with a 10-wheeled freight locomotive on the Chicago, Rock Island & Pacific Railroad, has been received from the Richmond Locomotive Works. If a saving of 25.4 per cent. of fuel can be maintained, without any increased expense in other directions, the case for compound locomotives is proved. The report contained in the tabular statement was furnished by Mr. George F. Wilson, Superintendent of Motive Power and Machinery of the line referred to.

ENGINE TEST—10-WHEELED ENGINES.

ILLINOIS DIVISION OF CHICAGO, ROCK ISLAND, AND PACIFIC RAILWAY.

RICHMOND COMPOUND, No. 2427. Cylinders, 19" and 30" × 24"; Driving-Wheels, 62"-diam.; Condition, out of Shop 9 Months.						ROCK ISLAND SIMPLE, No. 808. Cylinders, 19" × 24"; Driving-Wheels, 62" diam.; Condition, just out of Shop.					
DATE.	Number of 100-Ton Miles.	Lbs. of Coal Used.	Lbs. of Coal per 100-Ton Miles.	Ounces Coal per Ton Mile.	Actual Running Time.	DATE.	Number of 100-Ton Miles.	Lbs. of Coal Used.	Lbs. of Coal per 100-Ton Miles.	Ounces Coal per Ton Mile.	Actual Running Time.
June 17	2,152.50	16,770	7.70	1.232	8.20	June 18	2,104.78	25.800	12.25	1.960	8.36
" 20	1,834.74	15 4 0	8.39	1.342	6.50	" 19	1,696.08	20.000	11.80	1.889	8.10
" 23	1,884.54	15.900	8.43	1.349	7.25	" 22	1,608.89	15 950	9.92	1.587	7 20
" 25	1,788.62	16.880	9.43	1.509	6.30	" 23	1,776 64	17.600	9.90	1 584	6.55
" 26	2,193 25	18.030	8.22	1.315	7.45	" 24	1,932.67	21.400	11.07	1.771	8 31
" 28	2,068.33	16 000	7.73	1.237	7.20	" 26	1,365.45	15.850	11.60	1.856	5.45
" 30	2,065.80	16 350	7.91	1.265	7.20						

Average lbs. of coal per 100-ton miles	Richmond Compound	8 27	Saving for Compound, 25.4 per cent.
	Rock Island Simple	11.09	

AERONAUTICS.

UNDER this heading we shall hereafter publish all matter relating to the interesting subject of Aerial Navigation, a branch of engineering which is rapidly increasing in general interest. Mr. O. Chanute, C.E., of Chicago, has consented to act as Associate Editor for this department, and will be a frequent contributor to it.

Readers of this department are requested to send the names and addresses of persons interested in the subject of Aeronautics to the publisher of THE AMERICAN ENGINEER.

SPEED IN MIGRATORY FLIGHT OF BIRDS.

BY KARL MILLA.

WE condense from the Proceedings of the Ornithological Society of Vienna, the following report of an interesting lecture delivered before that Society on the 31st of January, 1895, by Herr Karl Milla, of Vienna, a well-known aviator and author, who was also the Secretary of the Aeronautical Society of Vienna (Austria.) The foot-notes have been added by the present editor.

THERE appeared some years ago a book by Henrick Gätke, entitled "The Bird Refuge of Heligoland," in which the author recorded his very valuable experience and observations upon the doings and life of birds, collected during fifty years on the lonely island of Heligoland.*

In this book Gätke makes some statements concerning the speed of birds in migration, which appear so remarkable that they probably aroused a great deal of incredulity. I, too, felt somewhat startled, and as I have busied myself for years with this question of bird flight, I may now venture a contribution on this subject, one of the most difficult problems to be found in nature.

According to Gätke's observations, concerning the accuracy of which there can now be no doubt, the "gray crow" flies over the North Sea, a distance of 80 German geographical miles (each 4.61 English land miles) in three hours, which is equivalent to a speed of 55½ metres per second (124 miles per hour); and yet this bird, as is well known, does not belong to those most expert in flight. Nor does a singing bird, like the northern "blue neck," belong among the best fliers; and yet, according to Gätke, it develops a speed of 45 German geographical miles per hour, or of 92 metres per second (205 miles per hour). The highest speed of all is found, on the authority of the same veteran observer of Heligoland, in the "Virginia rain-piper." This bird covers the enormous stretch, from Labrador to Northern Brazil—that is to say, 800 German geographical miles—in a single flight of 15 hours. This would be equivalent to a speed of 109 metres per second—253 miles per hour—a velocity almost monstrous.†

The result of his observations and conclusions force Gätke to make the following statement (page 74 of his book): "The proven speed of flight in the 'Virginia rain-piper' is so very great that we are forced to the conclusion that it is made possible only by some other means beside the mechanical apparatus with which the bird is equipped."

As a matter of fact, such calculations as have been made concerning the speed which birds attain, by means of their mechanical appliances alone, indicate that those speeds are far less than those observed by Gätke. Let us take, for instance, one of the better fliers, a 'mouse-buzzard' (kite). One of these, measured by myself, weighed 0.927 kilogrammes (2.04 lbs.), and spread a total supporting surface of 0.2469 sq. metres (2 65 sq. ft.), a ratio of 1.3 sq. ft. per pound. It should be noted that not only the wings, but the tail and underside of the body, help in carrying the weight, and that all these parts are included in the above area.

The law of air support, which we know to-day with some accuracy, and will use to determine the velocity of flight, may be expressed by the following formula:

$$P = a \times 0.13 \times F \times v^2,$$

in which P is the lifting power of the air, which in calm air is produced by the motion of the bird, and is equal to its weight.

v is the velocity in metres per second;

a is a variable coefficient, which lies betwen $\frac{2}{3}$ and 1, according to the angle of the wing;

F is the carrying area as defined above.

The above coefficient a is the result of the investigations of Otto Lilienthal upon concave surfaces, such as birds' wings. The present lecturer has discussed its application to the phenomena of bird flight in his book, "The Flying Motions of Birds," Leipsic and Vienna, 1895.

Suppose now the most favorable case—*i.e.*, an exact horizontal position of the wings, at which we presume the bird will be able to fly with the least expenditure of work. The coefficient, according to Lilienthal, will then be about $\frac{2}{3}$, and we have for the velocity required for support:

$$P = 0.4 \times 0.13 \times 0.2469 \times v^2, \text{ but } P = 0.927 \text{ kg.};$$

$$\text{hence, } v = \sqrt{\frac{0.927}{0.4 \times 0.13 \times 0.2469}} = 8.5 \text{ metres,}$$

or 19 miles an hour, at which velocity the "mouse-buzzard" is just able to sustain himself.

It is to be noted further that, to a certain extent, the smaller are the birds, the larger are their wing surface in proportion. It follows from this that small birds can be supported at less speed of flight than larger birds. I give calculations for two extreme cases.

A house swallow, with a weight of 16.4 grammes (0.036 lbs.) and an area of 113 sq. centimetres (0.121 sq. ft.), would need under the same conditions as above stated for the "mouse-buzzard" a speed of but 5½ metres per second (11.7 miles an hour) for support; while, on the other hand, a heavy bird, like the albatross, which weighed 12.7 kilogrammes (28 lbs.) and measured 1.78 sq. metres (19.15 sq. ft.) of supporting surface, requires more than twice the above velocity, or 11.7 metres per second; say, 26 miles per hour.*

Now, these calculated velocities are very small when compared with the bird velocities already given as the result of observations. The discrepancy cannot be bridged over even by doubling the above computed speeds, and I therefore agree with the watchman on the parapet of the Heligoland bird rest, when he says that some other power besides the muscular force of the birds must be acting, if it prove quite true that the real velocities of bird flight are not a paltry $8\frac{1}{2} - 5\frac{1}{2}$, or 12 metres per second (19.12, or 26 miles per hour), but are more than 100 metres per second, or 223 miles an hour.

But I disagree with him in his opinion that these high velocities are accounted for by the decreased density of the higher strata of air in which the migration of birds usually takes place † He says, on page 75 of his book: "In treating of the height at which birds fly when migrating, the fact has been explained more in detail that birds alone, among warm-blooded animals, are provided with a respiratory apparatus which enables them to remain a long time in thin strata of air, containing but little oxygen, even as high up as 40,000 ft. above the sea, and that they are equipped with a very complete system of air sacs, which they are able to fill or to empty at will. Those organs have no use at all apparent in the every-day life of the bird; still they must serve some purpose. This purpose may be solely in making possible these truly wonderful migratory flights; wonderful in the great height and speed at which they are carried out. If the birds during their fall and spring migrations were limited to the same lower air strata in which they move during the rest of the year, many of them would be hindered from carrying out their journeys in consequence of storms. For this reason they rise to greater heights, which are usually less subject to

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* Heligoland is a rock 200 ft. high and about 5½ sq.m. in area, in the North Sea, off the mouth of the river Elbe. It lies nearly in the track of one of the main migrating-routes of the littoral for birds, proceeding from the Baltic to France and Italy, or *vice versa*.

† The lecturer does not state how these speeds were ascertained, and in view of their extraordinary character, communications are invited from naturalists and others having knowledge of similar performances by birds.

* These velocities are probably underestimated; first, because the lecturer has made no account of the difference in the shape of wings of various birds, that of the swallow being notably flat in action, and second, because he has applied to the *whole* surface, part of which is convex, the coefficients obtained by Lilienthal upon concave arched wings alone. These considerations, with the further point that the horizontal position may not be that of minimum work, may increase the computed speed by 50 per cent., but this in no way invalidates the subsequent argument of the lecturer.

† Marey, in "Le Vol des Oiseaux," page 36, quotes the following velocities as given by Jackson:

Quail,	38	miles	per hour;
Pigeon,	60	"	" "
Falcon,	63	"	" "
Eagle,	69	"	" "
Swallow,	150	"	" "
Martin,	200	"	" "

These are presumably near the surface of the earth.

violent changes in the direction and turmoil of the wind. They also reach heights at which the decreased resistance of the lighter air makes possible their remarkable increase in speed, which yet counteracts the tendency to fall, as a very slight raising of the forward edge of the wing restores the required support.

"Through these considerations, the proven speed of migratory flight is not only more easily understood, but its existence may even be considered as demonstrated"

I must emphatically contradict this view. All the more as it has been adopted by others. Thus W. Berdrow (*Prometheus*, 1894, page 229) not only agrees with Gätke, but even goes further and says: "In this way—*i.e.*, by flying at great heights, according to the wonderful laws of air resistances, the work necessary may easily diminish to one-tenth or even one-twentieth of that necessary at the surface of the earth."

Now, in the first place, it is not proven that migrating birds really do fly at such enormous heights as 40,000 ft. above the sea.* Gätke, it is true, estimates it at this height, but we should consider two things: 1. An estimate is not a measurement, and such measurement is most difficult even when near the earth in transparent air; and 2. The mere vanishing of the bird to the eye of the observer is no proof against mistakes, as we may expect differences to intervene in the moisture, and therefore in the transparency of the different strata.

But even granting that the birds are able to fly at these enormous heights, still "the wonderful laws of air resistances" actually prove that the difference in the density of the air is not sufficient to account for the great speeds in question. The simple consideration that the thin upper air must still carry the *entire weight* of the bird, readily shows that the work done by the creature cannot be much less than that in denser strata.

Let us consider this theoretically. The work we assume to be the same in both cases, hence

$$A = a - \frac{B}{g} F v^3 = a - \frac{b}{g} F V^3.$$

This is the law for any resisting medium.

A in metres kilogrammes depends upon the coefficient a, which is a function of the form and sharpness of the flying body, but not of the density of the air, and which may therefore be left out of the above equation.

B and b are the weight of a cubic metre of air in the denser and in the thinner strata respectively.

F is also a constant for the same bird; its surface.

V and v enter into the equation in the third power.

g is the usual coefficient of gravity.

From the above equation we have:

$$B v^3 = b V^3, \text{ or } V = v \sqrt[3]{\frac{B}{b}};$$

or, to put it in words, the velocity in the thin stratum is to the velocity in the thick stratum as the cube root of the ratio between the respective densities is to unity.

For instance, assume a height of 20,000 ft., or 6,096 metres (about the height of Chimborazo); then the air pressure, equivalent to 365 2 millimetres of mercury, gives $b = 0.5968$ kilometres per cubic metre, if we suppose the temperature —10° C. with 50 per cent. moisture. At sea-level $B = 1.2936$ kilometres per cubic metre, barometer = 760 millimetres; hence we have

$$\frac{V}{v} = \sqrt[3]{\frac{1.2936}{0.5968}}, \text{ or } V = 1.2942\, v,$$

so that if a bird can fly 100 kilometres per hour in the lower and denser air, it will cover 129 kilometres per hour at the upper level, assuming that the work done is the same.

If we assume, with Gätke, a bird flying at a height of 40,000 ft.—that is, 12,192 metres above sea-level—the barometer at that height would stand at 141.6 millimetre, and the weight of a cubic metre of air would only be 0.265 kilogrammes. In this case the same formula gives $V = 1.6962\, v$—that is, the bird would fly about 170 kilometres per hour instead of 100 kilometres at sea-level.

From these figures it follows that the decreased density of the air does not explain the great speed obtained in the migratory flight of birds, nor the small amount of work which seems to be expended by them; so we must seek for some other cause.

Now there is another factor which accounts for these speeds —namely, the wind.

Gätke himself remarks (page 96) that "birds during their semi-annual migrations prefer to start in an easterly and southeasterly wind, even when gentle." He also quotes an observer in England, John Cordeaux, to the effect that on the east cost of Scotland, opposite to the island of Heligoland, the birds appear in large numbers when the winds are easterly and southeasterly; while but few birds arrive with the contrary winds; and that in the latter case these few birds probably flew very high.

Reasoning from this fact, determined by both observers, and from the further fact that if the bird be travelling in the same direction as the wind, it must have an additional speed of its own in order to obtain support, inasmuch as this is derived from a current passing its wings from front to back, it seems clear that if the wind be blowing at the rate of 40 metres per second (89 miles an hour), and the bird is rowing at the rate of 10 metres a second (22 miles an hour) in the same direction, it will actually travel 50 metres per second, or 111 miles per hour.

It now becomes a question whether the wind can reach such great velocities as are here assumed. Upon this point the observations of wind velocities made at the Eiffel Tower leave little doubt, as the speed is found to increase with the altitude, and on December 20, 1893, a velocity of 44 metres per second (98 miles an hour) was observed at the top.

Aeronauts have measured velocities of even 52 metres per second (116 miles an hour),* and have generally stated that the higher up they went the faster they travelled, so that we may assume as reasonably certain that at high altitudes (though we do not mean by this heights of 20,000 ft. to 40,000 ft. above the sea) great velocities do frequently occur.

As we know by the valuable observations of Gätke that birds are gifted with a very delicate premonition of changes in the weather, and further, that they frequently postpone their departure,† we may conclude that they are simply waiting for the right weather for their journey, and that they select the strata of air which move with the greatest velocity in approximately the right direction, in order to reach the end of their voyage in the quickest and surest way.

Inasmuch as the real speed of various birds is very hard to measure and very little known, save for carrier pigeons, whose velocity in still air is about 60 miles an hour, we cannot now say what is the normal speed of the migrating birds which have been above mentioned in the lower strata of the atmosphere; but as the work required for flight grows rapidly, or as the cube of the velocity, we cannot reckon upon any material increase of their speed obtained by a greater expenditure of muscular energy in the upper strata of air. Still less can "a slight lifting of the upper edge of the wing counteract the tendency to fall," as Gätke suggests. On the contrary, we know by the laws of flight that this apparently slight lifting lies heavy on the balance in a long-continued journey, because it increases the work to be done, while it decreases the speed of motion. It is the increased speed, without any change in the angle of incidence of the wing, which not only prevents sinking, but makes the flight possible with comparatively small expenditure of energy.

All considerations thus bring us to the conclusion that the skilful utilization of the force of the wind must be the only and sufficient extraneous means employed by the feathered wanderer to achieve the wonderfully fast flights which have been observed; and even if, by my explanations, I have succeeded in clearing up somewhat the obscurity surrounding this phenomenon, the performance still remains, and will continue to remain, a truly wonderful achievement, full of promise for the time when man shall learn to imitate the birds.

AN AERIAL YACHT.

RECENT French newspapers state that a navigable pleasure balloon is now under construction for Mr. E——, a well-known and learned archæologist and numismatologist, who proposes to utilize it for aerial trips upon pleasant days when there is little wind.

* The height of migratory flight is usually estimated at one or two miles by naturalists. The condor soars perfectly well at a height of two miles above the sea in the Andes.

* The following are the speeds of a few balloon journeys:
1810. Garnerin, 36 metres, or 80 miles an hour.
1850. Green, in the *Nassau*, 64 metres, or 143 miles an hour.
1868. Fonvielle and Tissandier, 35 leagues, or 105 miles an hour.
1870. "General Chanzy," 129 kilometres, or 79 miles an hour.

† It is not uncommon for migrating soaring birds to mount high in the air by circling, and then to circle down again to the point of departure; repeating this sometimes several days in succession, until, the circumstances aloft having apparently become favorable, they are off upon their course.

The designs have been made by Mr. H. de Graffigny, the well-known aeronaut, and are interesting as indicating the best modern practice.

This yacht is to carry two persons, and to achieve a speed of 19 miles an hour in still air. It is to be of elongated shape, 98 ft. long and 22½ ft. in diameter at the greatest section, being thus in the proportion of 4.35 to 1. In shape it consists of a section of a cone 39 ft. long, with ellipsoids of revolution at each end. The skin consists of strong cotton cloth, with an ultimate resistance of 700 lbs. per lineal foot on the woof, varnished with four coats, and weighing 0 06 lbs. per square foot. The total surface of this long spindle is 613 sq. ft., and it is to contain 26,500 cub. ft. of hydrogen gas, with a theoretical lifting power of 0.074 lbs. per cubic foot. There is to be the usual valve at the top, and an "appendix" or relief sleeve at the bottom, but no interior air bag, as the trips are to be short.

The car is to be suspended by a "saddle-cloth" fitting the upper half of the balloon closely, instead of the ordinary netting. This "saddle-cloth," made of 270 sq. ft. of the same material as the balloon, but not varnished, is substituted for the purpose of obtaining a uniform distribution of the weight, and of diminishing the friction of the air. Its lower end is provided with a hem, into which small wooden rods are inserted. Eyelet-holes in the hem admit of inserting the suspension cords for the reducing meshes, the strains being thus equalized upon the "saddle-cloth" through the rods, and any pitching effects due to movements of the gas in the balloon distributed lengthways.

The car consists of a frame of wood and rattan, with woven wicker panels and a wooden floor. It is 13 ft. long and 3½ ft. wide. At the front and at the rear there is an extension pole 16 to 20 ft. long, securely fastened to the car, which thus is lengthened out to 45 or 50 ft., and provided with a sort of keel. To this keel are attached the 36 suspension cords descending from the lower extremity of the "saddle-cloth," and it, moreover, supports the shaft which actuates the propelling screw, as well as the pivot for the rudder. The whole system is stayed by diagonal ties, and the keel is, moreover, connected by lines to short sections of netting fastened to the nose and rear end of the balloon.

The weights are to be approximately as follows:

Balloon, 613 sq. ft.	352 lbs.
Saddle cloth, 270 sq. ft.	75 "
Valve and appendix	26 "
Cords, ties, etc	44 "
Poles and fastenings	53 "
Car complete	44 "
Anchor, guide rope, etc	66 "
Total	660 lbs.

Allowing for impurities in the gas, and a consequent lifting power reduced to 0.066 lbs. per cub. ft., the balloon can sustain 1,750 lbs., or 1,090 lbs. more than its own weight, which surplus may be utilized as follows:

Aeronaut	143 lbs.
Passenger	165 "
Ballast	176 "
Motor, etc	616 "
	1,090 lbs.
Weight of balloon	660 "
Total lift	1,750 "

Thus it is seen that the possible weight of the motor, including its supplies of fuel, etc., for a trip is limited to 616 lbs. Inasmuch as the resistance of the largest section, of 398 sq. ft. area, is estimated at 77 lbs., at a speed of 19 miles per hour, it is calculated that the energy required is 4 H.P. upon the screw-shaft, or 8 H.P. at the engine, after allowing for losses. This therefore limits the motor alone to a weight of about 61 lbs per H.P. exerted. This problem is said to have been solved, although, pending the issuance of some patents, no indications are given as to the kind of motor adopted, save that it can develop 10 H.P. for two and one-half hours, and rotate a screw of 37 sq. ft. area at 90 turns per minute.

The whole apparatus is expected to be completed in August, 1895, and accounts are promised of the results attained on its trial trip.

A NEW AIR PROPELLER.

A LATE issue of the Paris *Gaulois* states that the committee on new inventions of the French Ministry of War is looking into the merits of a new form of aerial propeller for balloons, which is said to be novel and effective.

The novelty is stated to consist in the abandonment of the screw principle, which experiment has hitherto failed to improve, substituting therefor a system of vanes, both light and powerful, which is claimed to result in greater normal air pressure.

The new propeller is said to exert a thrust upon the air of 87 lbs. per H.P., while the screw has hitherto given but about half of this thrust; thus reversing the experience which has hitherto obtained with rotating vanes, the latter having always been found decidedly inferior to the screw.

Experiments would already have taken place at Meudon, had not the inventor, who lives at Limoges, refused to communicate his plans to the Ministry of War. He says the commission must come to him if it wishes to be convinced.

AERIAL ADVERTISING.

PROFESSOR CARL MYERS, the well known aeronaut, resides near Frankfort, N. Y., on what he calls his "balloon farm," and here he collects and manufactures the apparatus used by him in his ascensions, and also makes balloons and other aeronautical apparatus to order.

Recently the introduction of the life-saving balloons for conveying lines from wrecked vessels to shore caused world-wide notice, and no later than last week Professor Myers had orders for an outfit from Russia. Now he has been giving his attention to the production of balloons for advertising purposes.

The outfit for this purpose consists of a portable hydrogen gas generator of a type patented and in use by Professor Myers during several years, in connection with a light captive balloon capable of raising a variety of matter for advertising purposes. A balloon of this kind, 12 ft. in diameter, was completed recently, and bore on two opposite sides the words Columbia Bicycles, in huge letters of dark blue, the colors of that 'cycle. This, held captive at a height of 400 ft., made a conspicuous mark in the sky.

The entire outfit was built especially for the Pope Manufacturing Company, of Hartford, Conn., and was shipped Monday to Asbury Park, N. J., to be exhibited there during the bicycle parade. A bicycle glittering in nickel and aluminum was to be suspended from it, and the use of this "sky-bicycle" will be made regularly in bulletining events of the field as they occur; so that any notable result, world record-breaking or prizes captured, may be almost instantly communicated by placards to tens of thousands of people, widely spread over the entire section. This is "aerial telegraphy," indeed! No other possible way exists for notifying a crowd of the results of any speed or other contest so directly.—*Utica Observer.*

VELOCITY OF AIR CURRENTS.

To the Editor of AMERICAN ENGINEER:

Since the velocity of air currents which are to be encountered at different altitudes must be a subject of interest and importance to all who may attempt aerial flight, a summary of the measurements made at the Blue Hill Meteorological Observatory, near Boston, during 1890 and 1891 will perhaps prove useful to your readers. Measurements of the velocities of clouds at all altitudes were made with specially constructed theodolites at the ends of a 1,178 metre base-line and the results calculated with great care. The following table shows the mean cloud velocities in metres per second found between each successive difference in elevation of 2,000 metres:

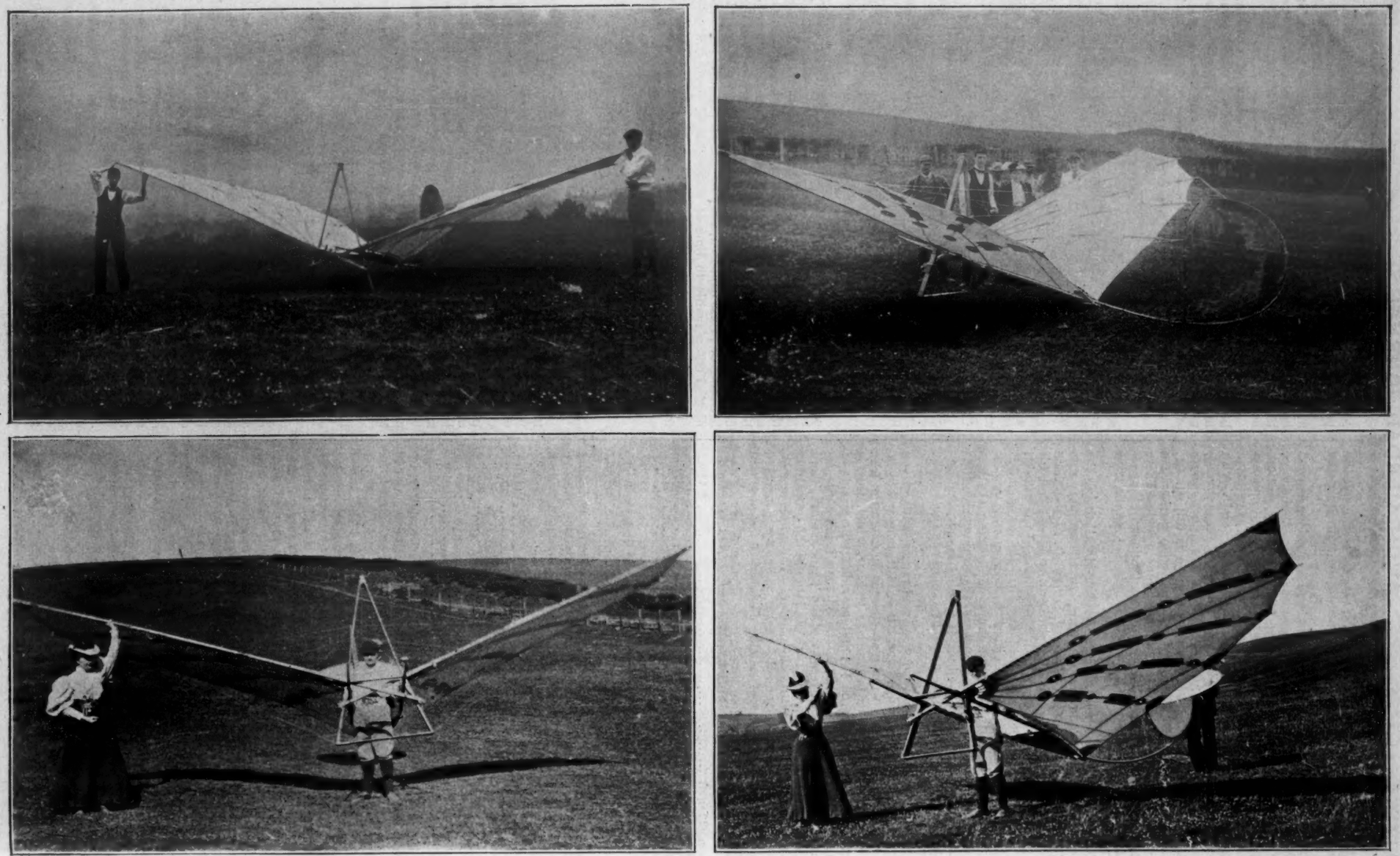
MEAN CLOUD VELOCITIES IN METRES PER SECOND AT INTERVALS OF 2,000 METRES ELEVATION.

Height in metres.	200 to 1,000	1,000 to 3,000	3,000 to 5,000	5,000 to 7,000	7,000 to 9,000	9,000 to 11,000	11,000 to 13,000
Summer	7.5	8.2	10.6	19.1	23.5	31.1	35.2
Winter	8.8	14.7	21.6	49.3	54 0		
Mean	8.1	11.4	16.1	34.2	38.8		

If these results are plotted it is seen that the velocity increases with altitude, both summer and winter, almost along a straight line—in other words, the increase of velocity with altitude is regular and uniform above 200 metres. If difference in altitude be represented by dh and difference in velocity by dv, then in summer $dv = dh \times 0.0027$, and in winter $dv = dh \times 0.0065$.

But since experiments in aerial navigation are at present confined to the vicinity of the earth's surface, the following table giving the increase of wind velocity per 100 metres found for mean differences of elevation of 200 metres during the summer will perhaps prove of greater interest:

Height in metres..	400 to 600	600 to 800	800 to 1,000	1,000 to 1,200	1,200 to 1,400	1,400 to 1,600	1,600 to 1,800	1,800 to 2,000	2,000 to 2,200	2,200 to 2,500	2,500 to 2,850	2,850 to 3,300
Increase in Veloc. per 100 metres.	+1.0	+0.9		−0.1		+.05		+0.1		+0.1		
		+0.7		−0.7		−0.1		+0.3		+.05		+0.4



PILCHER'S SOARING MACHINE.

The increase of velocity here given is the increase in metres per second between each successive 200 metres, and is found by comparison of cloud and wind velocities. The slight decrease in velocity found between 1,000 and 1,400 metres is probably caused by the ascending slower moving currents from a lower level by which the cumulus clouds at that level are formed. The mean of the first six of the numbers in this table give a mean rate of increase of 0.28 metres per second per 100 metres, as does also the mean of the second six and the mean of all. This would make the formula for the rate of increase in summer $dv = dh \times 0.0028$, which agrees very closely with that previously given for summer.

The extreme velocities which are likely to be encountered at each altitude are indicated by the following mean and maximum velocities of cloud forms which float at different altitudes :

Mean height in metres.....	8,884	6,633	3,856	1,614	508
Mean velocity in metres per second.....	38 5	32.5	15.7	11.3	8.7
Maximum velocity in metres per second...	102.6	66.9	33.0	30.8	18.0

The maximum wind velocity for five minutes found in ten years' continuous record on top of Blue Hill, which is 202 metres above sea-level, and about 6 miles from the sea-coast, is 39.4 metres per second ; but this is probably at least 20 per cent. too high, since it is well known that the anemometers now in use in the United States and elsewhere record velocities considerably too high when the wind is above 10 miles an hour. H. H. CLAYTON.

PILCHER'S SOARING MACHINE.

THE engravings which we give herewith illustrate a soaring machine made by Percy I. Pilcher, Esq., Assistant Lecturer to the Naval Architecture and Marine Engineering Class at the Glasgow University, and Draftsman in the shipbuilding firm of Messrs. J. & G. Thomson, Clydebank. The machine was made to try to repeat the very successful experiments made by Herr Lilienthal, of Berlin. It consists of five parts—*i.e.*, a body piece, a triangle, wings, and a rudder.

The body piece forms the centre of the machine ; on it the experimenter rests ; the back half of this is canvased in, while at the front the spars project like two bowsprits.

The triangle is fixed on to the body piece at the front of the machine, and each side of it passes through a quadrant-shaped steel plate, which is screwed to the body piece and also to the front spars of each wing.

The wings are made of nainsook, the most suitable material to be had at a moderate price. Their shape can be clearly seen in the pictures ; their area is 150 sq. ft. The extreme point of each sail is elevated 4 ft. above the body piece, to the spars of which their inner edges are laced. The sails are kept quite rigid by piano-wire bracings, which come from the apex of the triangle to three points on the upper side of each rib, while the same number of wires are drawn from the under side of each rib to each side of the base of the triangle.

The front spars of the sails cross each other in front of the triangle, and their extremities are lashed to the opposite sides of the triangle, while the inner end of each of the ribs, which are much lighter than the front spars, is finished with a small steel plate, which is fastened by means of a bolt to the quadrant-shaped steel plate on the triangle. The machine is made entirely of white pine, and its total weight, including sails and rudder, is 44 lbs. Mr. Pilcher has permission to practise on a hill at Wallaceton Farm, Cardross. This hill has a fairly steep slope toward the prevailing wind.

The first two days of practice there was an absolute calm, when he simply ran down the hill with the machine, the air taking the entire weight off his feet—*i.e.*, his own weight and that of the machine. He found it necessary to make some slight alterations in the balance of the machine, and also to substitute a vertical and horizontal rudder, as shown in the last two pictures, for the original one, which was vertical only and much smaller.

On the third day's trial there was a wind of 15 miles an hour, unfortunately rather puffy, blowing up the hill from which Mr. Pilcher experiments.

Having rigged at the foot of the hill, he cautiously and with some difficulty proceeded up the hill backward, the wind taking all the weight of the machine ; then, slightly elevating the front edge of his wings, he was taken up 4 ft. into the air, and remained there poised for ten seconds, when, throwing his weight slightly forward, he came down on exactly the same spot as he went up from.

Afterward he ran down the hill several times, taking, without any effort, leaps of up to 60 ft. in length at about 2 to 3 ft. from the ground. Being caught by a side puff, the machine was blown over, and the front starboard spar was too much broken to mend on the field. The following week Mr. Pilcher repeated these experiments with much the same success, but again broke one of the spars. He attributes these accidents to the fact of his wings being so much elevated at the points that a puff of wind from the side can get under one wing and raise it while the other is sheltered. Therefore, before mending the machine described above, he has determined to build another on the same principles, but of entirely different structure, and with the wings very much less elevated. With this machine he hopes to obtain better results. The machine weighs slightly more, but has a correspondingly larger sail area. This machine Mr. Pilcher hopes will be ready for trial in a few weeks.

PILCHER'S SOARING MACHINE FOLDED FOR TRANSPORTATION.

AERONAUTICAL NOTES.

Observatory Balloons.—At the recent races between the sloop yachts *Vigilant* and *Defender*, Professor Carl Myers managed a captive balloon for the New York *Evening World*, in the car of which a reporter was stationed to telegraph the positions and manœuvres of the boats to the office of the paper. With the exception of a trifling difficulty on the part of the reporter in properly focusing his glasses, the scheme was eminently successful, and will probably be repeated at the races of the present month.

A WRITER in the *Deutsche Bauzeitung* has some ideas in regard to the method of propelling the air-ships of the future, which have a certain interest, although they are not altogether new. Regarding as necessary conditions of flight through the air the employment of sustaining planes, and of some propelling force, he says that, instead of the revolving helix commonly used, it would be, in many respects, advantageous to employ a simple jet of air to produce the reaction necessary for driving the craft in any desired direction. The water-jet has already been applied to the propulsion of steamers, with

rather indifferent success; but he points out that, for sailing through the air, a jet which could be directed to any quarter, at pleasure, by simply turning a valve, would have great advantages, as no other steering mechanism would be required; and the rotary fan for producing the blast would be a very compact affair in comparison with the helical propellers used, for example, in the Maxim flying machine.

New Flying Machine.—A son of Major Pope, an army surgeon in California, has been constructing a flying machine which he proposes to try on Angel Island—a very appropriate place to try such a machine. A California paper reports that "the young inventor recently took his machine to the heights on the south side of the island in order to have plenty of room and a fresh breeze.

"He felt sure that he was on the right track of success, so far as the principle and the scientific basis were concerned, but he was a little in doubt about his handiwork and mechanical skill. Perhaps the canvas and bamboo rods and cords would stand the strain of his 130 lbs. against a strong breeze; perhaps not.

"After taking his position within the framework, he turned his face and the front of the machine toward the west. Gently he tipped the wings so as to catch the wind, as does the kite. Then he took a few steps forward and—left the earth.

"Slowly he arose, like a seagull from the crest of a wave. But before he had soared more than 3 ft. from the ground there came a sudden collapse. An important brace in the light frame gave way under the strain, and one of the guide-cords snapped in twain.

"Down came the machine and the inventor; but his hopes still soared aloft. If he could not fly higher or farther just then, he had flown enough to convince himself and his friends that his work had not been in vain."

Mr. Pope, it is said, is only nineteen years old, and has built his machine in leisure moments, and it has many defects. He proposed to repair the damage, make it stronger, and he says he will fly. Success to him.

French Pigeon Flying.—The European edition of the New York *Herald* recently gave an account of the flying of very large numbers of pigeons in France. "The course," that paper says, was organized by the *Petit Journal*, and was intended to show the vitality of the pigeon breeding industry in that country. No less than 60,000 of pigeons, it is said, were let loose on the open ground between the Pont d'Iena and the Moulineaux Railway. The first start took place about four o'clock in the morning. The President of the Republic was present, and congratulated the pigeon breeders in France on the success of their efforts, which were of such importance to the defence of the country.

At the conclusion of the President's speech 5,000 pigeons, belonging to the Northwest, the West, and the Central regions, were released. The *coup d'œil* was extremely picturesque, the thousands of birds whirling round for some minutes in wide circles before streaming off in long columns toward their destinations.

Seventeen departures took place, the last being at half-past ten.

Explosive Aerial Navigation.—Dr. Edwin Pynchon, of Chicago, proposes to use high explosives as the motive power for aeroplane flying machines. The aerial machine is to be pushed forward by successive explosions of small quantities of dynamite. For work of this kind it is said it becomes simply a matter of "dosage," and after the exact power required is ascertained, it can be secured readily by regulating the quantity or charge of the agent employed on any given occasion. When exploded from the rear of a moving body, the shock of any given charge must be modified in ratio to the speed with which the body is moving, and further care be regulated by the size of the charge used. He thinks that with a ship about double the size of that now being constructed by Maxim, after a full speed of 200 miles per hour has been attained, it can be kept up by the explosion every five seconds of a pair of 60 per cent. nitro-gelatine cartridges, each weighing two ounces! No, thank you, doctor, we don't want to go on your first trip, while you are diagnosing the "dosage" of dynamite and nitro-gelatin "up in a flying machine."—EDITOR AERONAUTICS.

To the North Pole by Balloon.—The daily papers have recently had numerous accounts of Mr. Andree's project for reaching the North Pole by means of a balloon. The following letter from a correspondent in Sweden gives some definite information with reference to the actual progress which the scheme has made:

To the Editor of THE AMERICAN ENGINEER:

All the money—130,000 kroners—needed by Mr. Andree for his proposed North Pole expedition has been subscribed, and he is now busy making ready to carry out his great scheme.

The subscriptions were as follows:

Mr. Nobel (the great oil magnate)	65,000 kr.
King Oscar	30,000 "
Mr. Oscar Dickson, Gothenburg	30,000 "
A gentleman who wishes to be unknown	5,000 "
Sum total	130,000 kr.

A later number of the French paper, *L'Illustration*, gives the likeness of Andree and three pictures of his proposed balloon, with draw-lines and sail. With the illustrations is a text particularly remarkable, as it was written by the celebrated aeronaut, who is now over seventy years old, M. de Fonvielle, who has for many years been recognized among men of science, and who, together with the well-known Gaston Tissandier, undertook a number of balloon voyages. It will also be remembered how he, during the late Franco-German War, while Paris was all surrounded by the enemy, ascended in his balloon from the city, and successfully got around the whole German army.

M. de Fonvielle expresses himself in the most sympathetic manner with regard to the Andree North Pole expedition, of which he also gives a detailed description. He thereafter contradicts the opinion expressed by M. Faye in the French Academy of Science—the latter meaning that it would be almost impossible for the expedition, if it once reaches the North Pole, to get away from there. M. de Fonvielle replies that every expedition toward the Pole is, of course, combined with great risk; but if the members of the expedition will not make the stay at the Pole too long, they will be sure to have a safe return. M. de Fonvielle finally makes a comparison between the Andrie prospect and the late Nansen expedition, and says that if Nansen had offered him a place on his *France*, he would have declined the offer without hesitation; whereas his answer would be somewhat different were Andrie to give him a chance in his balloon. CARL G. LIDBECK.

TRANSIT IN AIR.

To the Editor of THE AMERICAN ENGINEER:

On page 291 of the June number of THE AMERICAN ENGINEER, under the title "Transit in Air," the writer assumes a "prevalent misunderstanding" in regard to the action or effect of inertia and momentum. He seems to ignore the principal factors in the whole case, and when he asserts that a flying machine, launched from a balloon above the clouds, might go off in any direction under precisely equal conditions without regard to wind and earth, he evidently forgets that there is such a force as gravity. If gravity could be eliminated from actual life as easily as it seems to have been from this writer's mind, successful flying machines would be quite common.

J. P. H.

AERONAUTICAL BOOKS.

PROGRESS IN FLYING MACHINES. By O. Chanute. 100 illustrations; 308 pp., 5¾ x 8½ in.; price, $2.50.

PROCEEDINGS OF THE CONFERENCE ON AERIAL NAVIGATION, held in Chicago, August 1, 2, 3 and 4, 1893. 429 pp., 5¾ x 9 in.; price, $2 50.

AERONAUTICS. 12 Nos., Oct., '93 to Sept., '94; illustrated; 8 pp., 8½x.1¾, 10c. each; $1.00 per set. Bound in cloth, $2.50.

AERONAUTICS. An abridgement of aeronautical specifications filed at the British Patent Office from A.D. 1815 to A.D. 1891. By Brewer and Alexander. 8½ x 4¼ in., 160 pp.; illustrated; price, $2.50.

A MANUAL FOR THE PRACTICAL USE OF AVIATORS AND AERONAUTS. (German.) Published by W. H. Kühl, Berlin, 1895. 198 pp. Price, $1.00.

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